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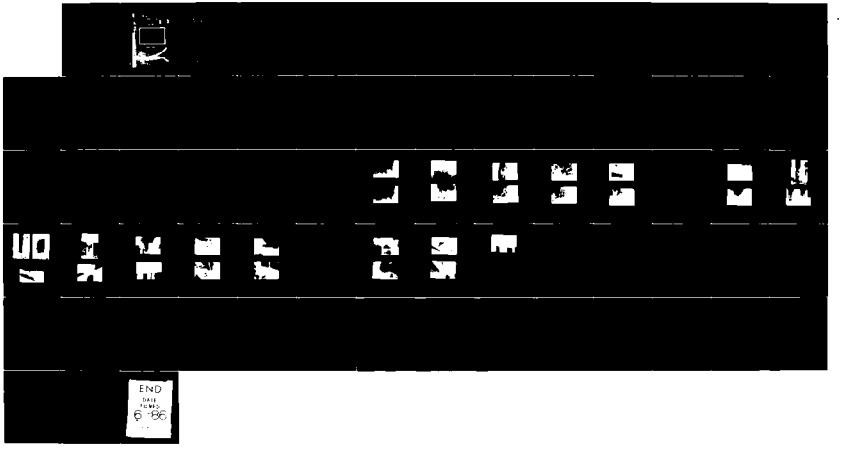

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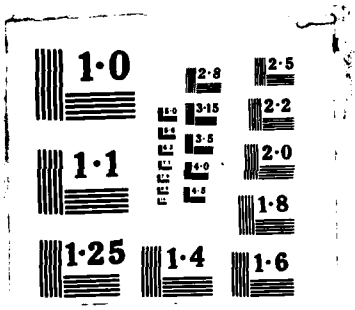
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UNDERWATER FACILITIES

INSPECTIONS

AND

ASSESSMENTS

AT

MARGINAL WHARF
TRIDENT REFIT FACILITY
BANGOR
BREMERTON, WASHINGTON

OCTOBER, 1980 FPO-1-80 (14)

Performed for:

OCEAN ENGINEERING AND CONSTRUCTION PROJECT OFFICE
CHESAPEAKE DIVISION
NAVAL FACILITIES ENGINEERING COMMAND
WASHINGTON, D. C. 20374

Under:

CONTRACT N62477-80-C-0233 - Task #1

By: WISWELL, INC.
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The objective of the underwater facility assessment conducted at the Trident Support Site, Bangor, Washington, is to provide a generalized structural condition report on this facility. Facility inspected was Marginal Wharf, located within the Naval Submarine Base, Bangor, Bremerton, Washington. (Con't)

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The inspection conducted at this facility was conducted by a three man crew consisting of 2 Engineer/Drivers and one Journeyman Diver, utilizing visual and tactile inspection techniques. Critical conditions discovered during the survey were documented in both photographs and on video tape. Approximately 20 percent of the piles supporting the wharf were inspected in detail while the remaining piles were inspected for major damage or deterioration during a swim-through inspection.

A total of 5 piles were found to have serious structural damage. All five of these piles are located in the outer or "A" row, closest to berthed vessels. All five piles appeared to have been damaged by impact. The remainging piles supporting the Marginal Wharf showed some signs of very minor damage or spalling that probably occurred during construction and showed no signs of major structural damage. With the exception of these deficiencies, the facility was found to be in good condition for its location and age.

FOREWORD

The scope of the underwater inspection at the Marginal Wharf at Bangor, WA and the detail to which it was performed and reported was tailored specifically to the conditions at this facility. This report and the procedure associated with its formation are not intended to be standards for inspections or reports covering other activities. Attempts are being made, however, toward establishing standards for procedures and formats for inspection and assessment reports. Through these standards, inspections performed by different persons, on many facilities and under a wide range of conditions can be effectively compared. It is expected that the inspection and assessment of the Marginal Wharf, like previous operations mandated under the underwater portion of the Specialized Inspection Program, will contribute significantly toward achieving that objective.

It should be noted that the choice of the level of inspection and the procedural detail to be employed will be an engineering judgement made separately for each activity/facility to suit its unique situation and needs. Accordingly, the procedures used at the Marginal Wharf, rather than serve as a detailed model for inspections elsewhere, will provide guidance with general applicability to some types of future inspections.

EXECUTIVE SUMMARY

The objective of the underwater facility assessment conducted at the Trident Support Site, Bangor, Washington, is to provide a generalized structural condition report on this facility. Facility inspected was Marginal Wharf, located within the Naval Submarine Base, Bangor, Bremerton, Washington.

The inspection conducted at this facility was conducted by a three man crew consisting of 2 Engineer/Divers and one Journeyman Diver, utilizing visual and tactile inspection techniques. Critical conditions discovered during the survey were documented in both photographs and on video tape. Approximately 20 percent of the piles supporting the wharf were inspected in detail while the remaining piles were inspected for major damage or deterioration during a swim-through inspection.

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U. S. NAVAL SUBMARINE BASE

BANGOR, WASHINGTON

EXECUTIVE SUMMARY TABLE

Facility	Year Built	No. of Bearing Piles*	No. of Batter Piles*	Facility Size	Pile Type	Recommendations	Estimated Repair Cost (Dollars)
Marginal Wharf	1944-1945	2127	261	87'4" x 1460' (Wharf)	Square Precast Concrete, 16 inch and 18 inch	Repair 5 piles showing structural damage (Piles 112A,115A,124A, 127A, and 138A). Inspect outer rows of piles after 5 years	$15,000
Marginal Wharf	1944-1945	34	68	12'6" x 340' (Trestle)	Square Precast Concrete, 16 inch	No severe damage. Inspect after 5 years	----

* Actual number of piles supporting structure. Varied from original G.F.I. due to two modifications to structure.

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SECTION 1 INTRODUCTION

This report is a product of the underwater inspection program conducted by the Ocean Engineering & Construction Project Office (FPO-1), Chesapeake Division, Naval Facilities Engineering Command (NAVFACENGCOM) under NAVFAC's Specialized Inspection Program.

This report specifically addresses below water conditions of the Marginal Wharf located at the U. S. Naval Submarine Base (SUBASE), Bangor, Washington. The purpose of this program is to provide a baseline assessment of the underwater portions of this facility, identify any conditions that may weaken the structural strength of the facility, and make recommendations for repairs to bring this facility back to original designed strength.

A brief description of the activity is provided to define location, mission, existing facilities, proposed facilities, hydrographic and topographic features, and other pertinent data. The location, function, construction and condition assessment of Marginal Wharf is also set forth.

The underwater inspection of the Marginal Wharf at SUBASE, Bangor involved a Level I inspection of the facility. Level I underwater inspections vary in scope but basically assess the general conditions of a structure, utilizing visual/tactile inspection techniques. This usually involves the inspection of a certain percentage of the structure in detail to determine specific conditions as well as a less rigorous inspection of all remaining piles. A Level I inspection is designed to give a general condition assessment of the structure and to identify any areas that have structural damage or are in advance states of deterioration. Documentation, by photographic means and measurements as deemed necessary is provided for verification of the findings.

1.1 TASK DESCRIPTION

The scope of work required under this portion of the program provides a general structural assessment including repairability, if necessary, of the underwater portion of the piles supporting the Marginal Wharf and Railroad Trestle located at the Naval Submarine Base in Bangor, Washington

1.2 REPORT CONTENT

In this report the inspection procedures, the results of the inspection and analysis of the findings are addressed. The facility examined is described as to its location, function, construction, inspection condition, and condition assessment. Recommendations for the facility are also included. A repair cost estimate breakdown can be found in the Appendix. Also, as supplementary information, a brief description of the Naval Submarine Base is provided to define its location, mission, existing and proposed facilities, hydrographic and topographic features and other pertinent data.

SECTION 2 ACTIVITY DESCRIPTION

2.1 LOCATION OF ACTIVITY

The Naval Submarine Base, Bangor, Washington, is located on Kitsap Peninsula in Puget Sound, due west of Seattle, Washington. The site is rural in nature. The site is tree covered, except for those areas cleared for facilities and for maintenance of site functions. The Activity is located at latitude N. 122° 42' and longitude W. 47° 43'. (See Figures 1 and 2)

2.2 MISSION OF ACTIVITY

The functions of the Naval Submarine Base, Bangor, include the following:

1) Ship refit. This function performs resupply, refit and repair operations. The refit facilities include shops, storage and staging and management center. A dry-dock and two refit berths are located at the waterfront.
2) Missile support. This function, The Strategic Weapons Facility, Pacific (SWFPAC) includes explosive handling wharves, storage facilities for the missiles and the production and assembly facilities. These facilities are similar in capacity to the Polaris missile facilities located at the present Polaris Missile Facility, Pacific, (POMFPAC).
3) Site support. This function, the Trident Support Facility, (TSF) provides the necessary physical security, administration, public works, housing, and other community and personnel support services and facilities required to maintain the site.
4) Training personnel support. The Trident Training Facility (TRITRAFAC) provides basic courses and refresher training for personnel to initiate and maintain professional skills necessary for operation of this system.

2.3 HISTORY OF FACILITY

Bangor Annex was originally known as the U. S. Naval Magazine facility, established between 1944 and 1945, as the Pacific coast trans-shipment point for ammunition and explosives. In 1950, the

Bangor Annex was consolidated with NTS, Keyport, to form the U. S. Naval Ordinance Depot, Puget Sound, Keyport, Washington. In April, 1952, the two activities were returned to independent status. The Bangor Annex was then titled the Naval Ammunition Depot (NAD), Bangor. In 1962, the Secretary of the Navy selected NAD, Bangor as the proposed site for the Polaris facilities to service the Pacific fleet. The Polaris Missile Facility, Pacific (POMFPAC) was established as a tenant of NAD, Bangor, in September, 1963 and went into full operation in December, 1964. In October, 1970, NAD, Bangor, was placed in inactive status and again made the annex of NTS, Keyport. In 1972 it was assigned an ordnance transshipment mission in support of southeast Asia operations.

The Bangor Annex consists of over 8500 acres. The major land uses consist of an Administrative and Personnel support area, a family housing area, industrial and production facilities, various type of magazines and barricaded sidings, Marginal Wharf, outloading facilities, the Polaris Missile Facility, Pacific, and a number of tenant activities.

2.4 EXISTING WATERFRONT FACILITIES

The waterfront facilities of this activity provide the interface between the submarines and the shore support activity. Five functional areas are required, i.e., 1) Refit, 2) Explosive handling, 3) Deperming/Degaussing, 4) Service, and 5) Marginal Wharf. The first three are program requirements for Trident Support Facilities. The fourth is a facility for NTS, Keyport, which replaces similar facilities displaced by Trident. The fifth is the existing Marginal Wharf which will remain intact with a reduced mission.

The existing Marginal Wharf will continue to have the north leg used to load and off-load Polaris missiles while the south leg will continue to be available for loading and off-loading conventional ammunition on an emergency basis.

It should be noted that the south leg of Marginal Wharf falls inside the K-11 (24 missiles) Q-D arc from the Refit Berths and therefore cannot be used in compliance with the requirements of OP-5. The south leg is physically usable and could be used in an emergency if a waiver could be obtained. There is adequate separation between the Refit Berths and the north leg of the Marginal Wharf and between the Explosive Handling Wharf and the entire Marginal Wharf.

2.5 CLIMATOLOGICAL & METEOROLOGICAL DATA

Climatic conditions on Bangor Annex are representative of the Kitsap Peninsula with short, cool, dry summers and mild, wet winters. Conditions are dependent upon the Pacific high and the flow of moisture-laden air which accompanies winter storms from the southwest. Annual precipitation, within a 30 mile radius of Bangor Annex, varies from 30 to 70 inches. Approximately 75 to 80 percent of annual rainfall occurs from October through March. Temperatures above 100° F. and below 0° F. are uncommon. The Kitsap Peninsula and Hood Canal areas are susceptible to slightly higher winds than other areas of the Puget Sound lowlands. For design purposes, the Bremerton figure of 38.66" of annual rainfall has been assumed usable for Bangor Annex.

2.6 TOPOGRAPHY

The Hood Canal shore of the Bangor Annex is for the most-part erosional with steep wave-cut slopes rising to more than 100' above sea level. The sea-shore environment is characterized by slow erosion of the cliff and the deposition of the erosional debris (silts and sands) from the streams to the off-shore deltas. The sea bottom slopes uniformly down toward the depths of the Hood Canal, generally at a slope of about one in ten. This slope is found to be steeper in front of the Marginal Wharf and outside other spits but flatter in the bay, between the Small Craft Pier and Marginal Wharf.

2.7 SOIL CONDITIONS & HYDROLOGY

A major portion of the Bangor Annex is covered with glacial till, a dense gravel-sand-silt mixture deposited and compressed by the weight of the glacial ice. The till is relatively impermeable. The thickness of the glacial till varies from 0 to more than 40', the thickest being in the southern portion of the annex. Older gravel deposits were found outcropping beneath the silt in the vicinity of Marginal Wharf. These older gravels were found to be very dense and where exposed, are generally weathered with layers up to 10' thick of hard silt and clay containing organic zones. Off shore, along the Bangor Annex shoreline, the sea floor is covered with recent loose to medium dense granular materials of varying depth. At some locations a wedge of till follows, thickening towards the center of the canal.

In the off shore area, artesian conditions occur in areas where silt strata exist. Presumably, water seeping towards the canal in these areas is trapped beneath the silt hence high water pressures can build up under silt layers whenever the distance to the nearest sea floor seepage outlet is more than several hundred feet. The existance, at several locations, of relatively impermeable till above appears to increase this artesian pressure. There is a balance of water recharge, slowly seeping to the upland hills into the underlying sands, and water seepage from these sands into Hood Canal. The balance is maintained by a head of water corresponding to the inland water table level, driving the ground water slowly into the canal through the soils. This seepage is quite irregular along the shoreline.

Tide level data for this facility is as follows:

Extreme High Water	(EHW) Elev. +	8.7
Mean Higher High Water	(MHHW) Elev. +	5.0
Mean Sea Level	(MSL) Elev. +	0.00
Mean Lower Low Water	(MLLW) Elev. -	6.7
Extreme Low Water	(ELW) Elev. -	11.1

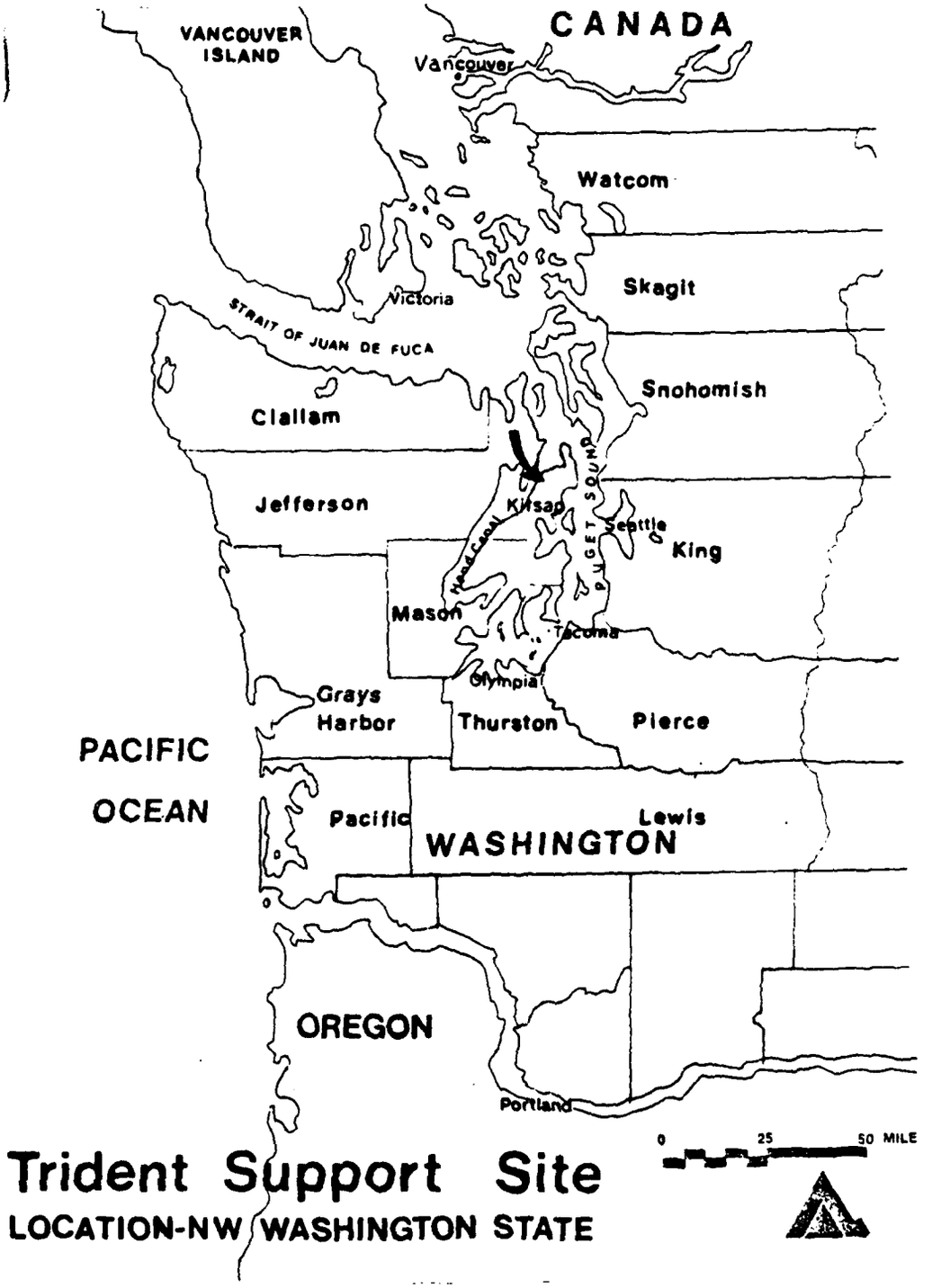

Figure 1 Location Map - Regional

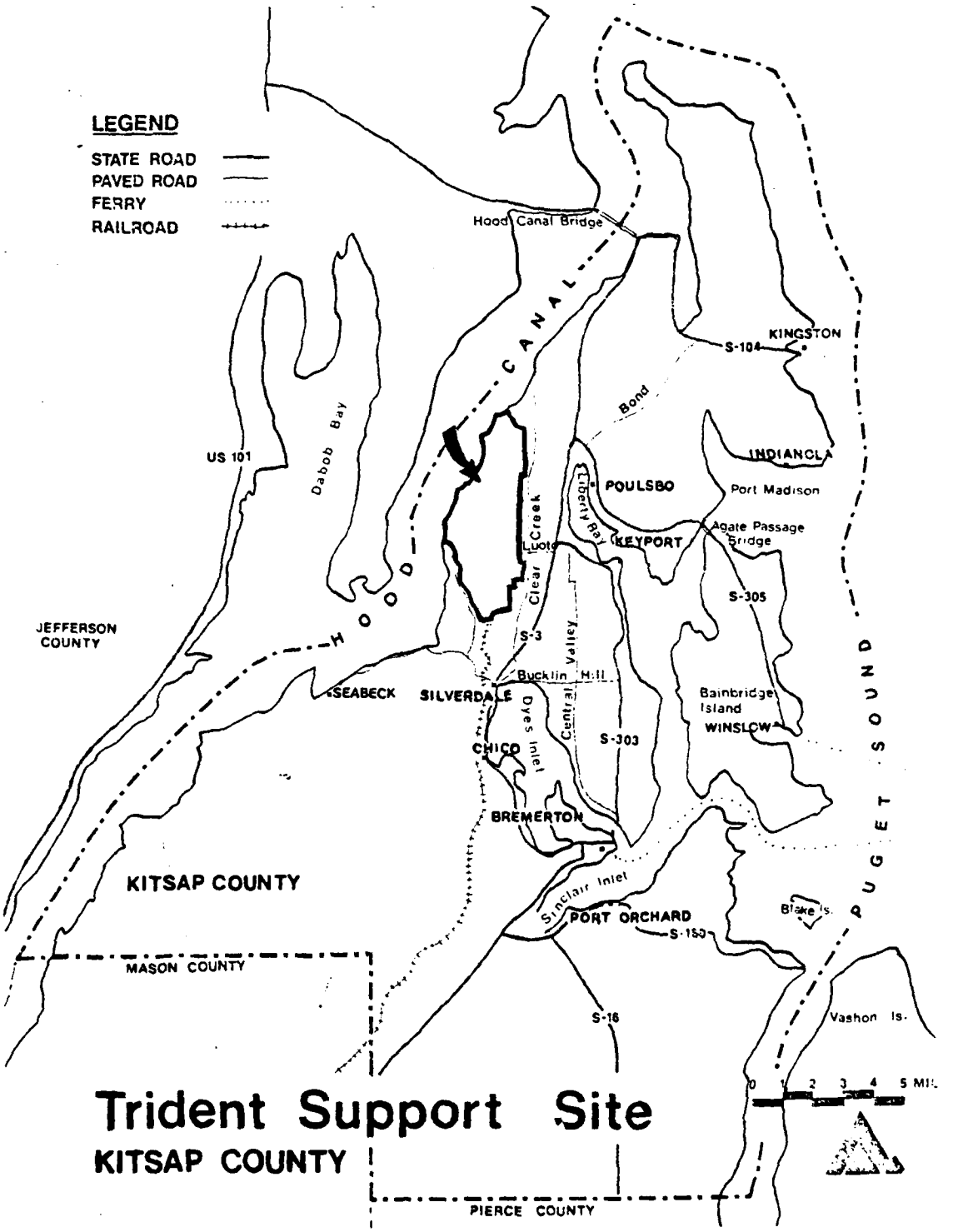

Figure 2 Location Map - Vicinity

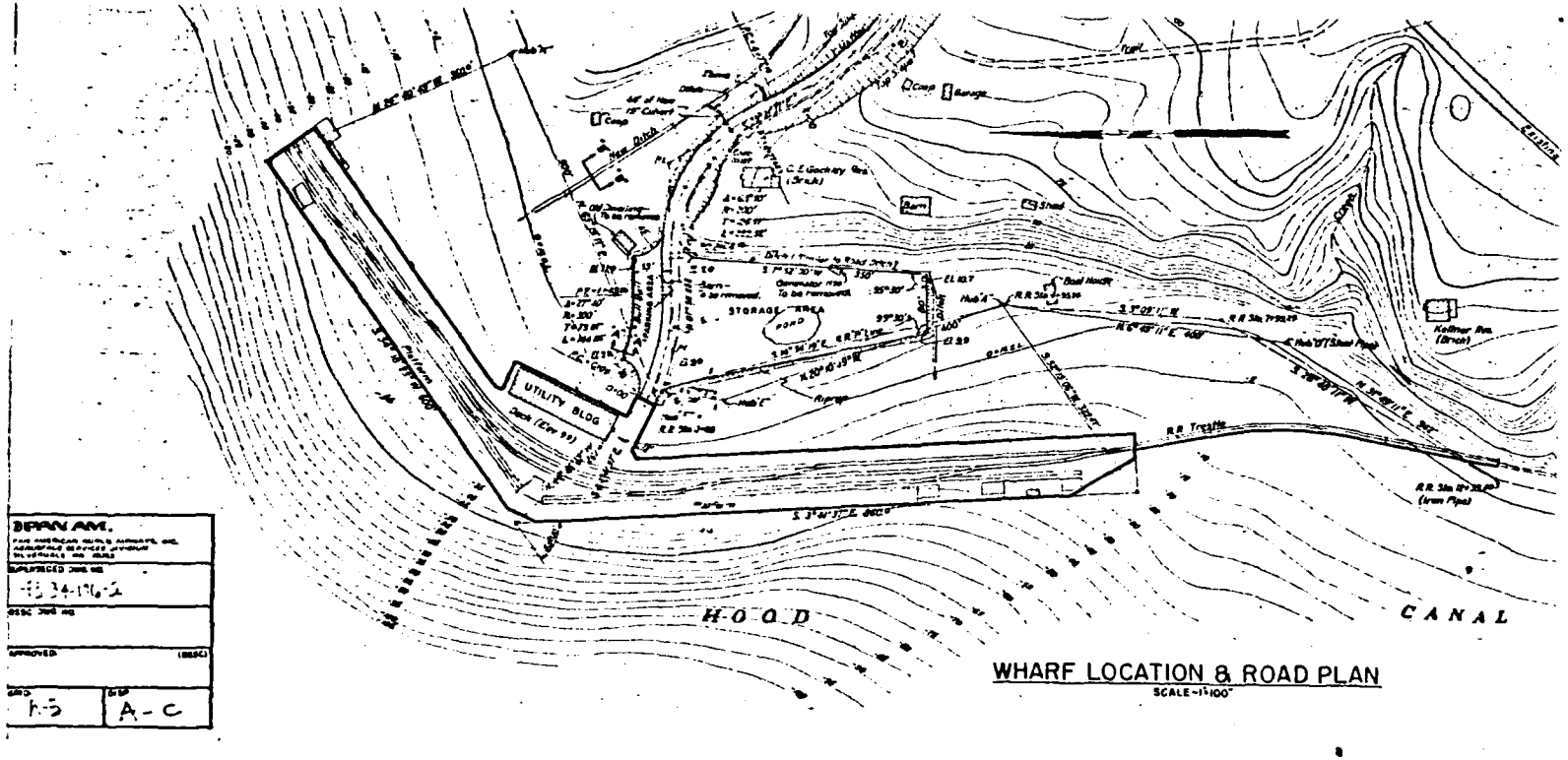

Figure 3. Wharf Location and Road Plan

SECTION 3 INSPECTION PROCEDURE

3.1 Level of Inspection

From September 29 through October 3, 1980, an inspection team consisting of two engineer/divers and one diver/tender performed a level one underwater inspection of the Marginal Wharf at the Naval Submarine Base in Bangor, Washington. Level one underwater inspections assess the general condition of a structure, utilizing visual/tactile inspection techniques. For pile supported structures, visual/tactile observations of a certain percentage of the structures' piles are performed. Documentation by photographs and video tape is made of conditions as required. This level of inspection is designed to give a general condition assessment of the structure and should identify any areas that have been mechanically damaged or are heavily deteriorated.

3.2 Inspection Procedure

Past experience, combined with engineering theory, the level of inspection to be performed, the type of structure being inspected and the actual onsite conditions dictate the inspection procedures to be used.

Under the original task description, the Level One inspection included 171 wood piles and a minimum of 20% of the concrete piles supporting the wharf. Upon arrival at the site, it was immediately determined that the wooden piles were actually the fender system, therefore, the inspection of the wooden piles was cancelled. To insure that an appropriate cross-section of piles supporting the wharf were inspected, every fifth bent was chosen for an in-depth inspection. The fender system, utilities, and above water structures were not in the scope of work for this inspection, but cursory examinations of these systems were made during the in-depth inspection of the structural piles.

Pilings under the wharf were identified based on the design drawings for the facility, specifically "Marginal Wharf - Piling Plan", Y & D drawing No. 332,152, Public Works Drawing No. 28904, dated 5/22/1944. It was noted that two modifications were made to the

pier that were not included on the general plans. An additional row of piles was included in the south leg of the wharf and the area where the wharfs' two legs join was increased with additional support piles. (See Public Works Drawing No. 28934). Where available, the same system of pile notation was employed by Wiswell, Inc. as set forth by the "as built" drawing.

The underwater inspection team consisted of two engineer/divers and one diver/tender. Due to the configuration of the structure, the depths involved, and to insure an accurate inspection and accurate note-taking, surface-air-supplied diving was employed. The dive station consisted of a compressor, volume tank, two-way communications radio, pneumofathometer, and back-up air supply system. This method of diving allowed the inspecting engineer/diver to describe, in detail, any damage or deterioration that was encountered via two-way communications. The inspecting diver would inspect a pile, cleaning growth as necessary, looking for cracks, voids, spalls, exposed reinforcing steel, or other signs of damage. After descending down one pile, inspecting it in a semi-spiral fashion to view each face, the engineer/diver would move to the next pile and ascend while inspecting for damage or deterioration.

The inspection of the facility included close examination for 3 major types of problems. These problems were mechanical damage after construction, damage during construction,and deterioration occuring since construction. Mechanical damage after construction was primarily limited to damage due to impact of berthing vessels. This damage was limited to the outer rows of each bent and the connecting pile cap. Damage during construction would primarily be cracks in the piles, when driven, which would then allow water intrusion into the piles and allow spalling and oxidation of the reinforcing steel. Deterioration of the piles would be in the form of erosion and chemical attack on the concrete piles.

Documentation in the form of still photographs and a video tape

was obtained of typical and irregular conditions. Photographs of damage and deterioration both under-water and above-water, but below deck level, were taken. Soundings were taken at locations along each bent.

3.3 Inspection Equipment

Equipment used for inspection of the piles included a sharp pointed probe, a Nikonos II under-water camera with Vivitar strobe, Hydro Products under-water TV system with video tape recorder, dive lights, 100' sounding tape, scraping tool and dive knives.

Choice of equipment was made as a result of past experience, chosen for its effectiveness and ease of operation in an under-water environment.

In conducting the inspection of Marginal Wharf, a variety of marine growth was encountered. On the outermost rows of piles on the wharf, marine growth was very heavy due to the available sunlight. This marine growth was heaviest in the tidal zone, with marine growth consisting of mussels, oysters, and barnacles. At lower elevations on the piles marine growth consisted of sea anemones and minor marine growths; at still lower elevations, near the mudline, marine growth was limited to small anemones and deposits which allowed the definite shape and edges of the precast piles to be clearly visible. The inspecting divers cleaned enough marine growth from the piles, as necessary, to determine if cracks, spalls, or other damage was present. This cleaning process in the worst cases consisted of a 6-inch path cleaned from the top of the pile to the mudline. When any irregularities were encountered, this cleaning process would include all surfaces necessary to determine the nature of the irregularity.

For the most part, underwater damage was limited to broken piles, probably caused by impact by berthing vessels. Damage located between the water line and the underside of the pier was found to be more extensive than the underwater damage and although this area is not specifically included in the scope of work for this project, the damage was detailed and photographed as part of this inspection.

4.1 Marginal Wharf

4.1.1 Description

Marginal Wharf is located along the Hood Canal at the Northern end of the base. Marginal Wharf is located between Delta Pier and the Explosives Handling Wharf.

The North leg of the Marginal Wharf is used primarily by Polaris Missile Facility, in the loading and unloading of Polaris missiles. The South leg is used primarily for

ammunition ships and missile-supplying vessels, with the loading and unloading of ammunitions.

The Marginal Wharf was constructed in 1944-45 and is a permanent reinforced concrete structure, with 1,460 linear feet of berthing space and a minimum depth of 45' of water along side at minimum lower low water (MLLW). The wharf deck is 87'-4" at its widest, with an approximate 22' wide loading platform at railcar-door height. The railroad trestle has an overall length of 340' and a deck width of 12' 6". The main pier consists of a North and South leg positioned at an angle of 58° from each other. The deck width of the pier, on the North leg, is 81'. Deck width on the South leg of the pier is 87' 4". The wharf deck was designed with a live load capacity of 600 lbs. per square foot, or a 12-ton truck with maximum wheel load of 15,000 lbs. The loading platform was designed with allowed live load of 800 lbs. per square foot, or a 15-ton wagon train with maximum wheel load of 19,000 lbs. at 5.33 feet, center to center. The designed pile load is 40 tons.

The Marginal Wharf consists of reinforced concrete decks supported by square concrete piles. The piles are 16" and 18" square reinforced concrete piles with chamfered corners. The maximum length for 16" piles used in construction was 59'. All piles over 59' long were 18" square reinforced concrete piles. A timber fender system is provided on the West face of the pier along both North and South legs. Materials for construction have the following design properties:

A) Concrete for deck: 3,000 PSI Ultimate strength
B) Reinforcing steel: Failure strength of 20,000 PSI

The railroad trestle is supported by 34 bents with 3 piles per bent. The center pile in the trestle bents is vertical with the 2 outside piles having a batter of 1:8. The piles in the main section of the Marginal Wharf are arranged in 172 bents. The South leg consists of bents 1 through 86, with most bents consisting of 13 vertical piles. Batter

piles are located in an alternating pattern of 2 bents of vertical piles only and 2 bents with vertical piles and batter piles. Those bents having batter piles have a total of 4 batter piles in the bent, 2 battered in an Easterly direction and 2 battered in a Westerly direction. (See Drawing P.W. No. 28,934). The North leg of the Marginal Wharf consists of bents 36 through 146, with most bents consisting of 12 vertical piles. Batter piles are positioned in this leg in an alternating pattern of 2 bents of just vertical piles adjacent to 2 bents of vertical and battered piles, with 4 batter piles in each bent. The batter piles are driven with a batter of 1:3. Hexagonal piles were located between bents from a modification made after the original construction.

The main approach to Marginal Wharf, and the section of wharf under the wharf facility buildings, is supported by 26 bents with from 4 to 6 piles per bent. An additional section of the wharf, located in the center, is supported by additional piles which are a continuation of existing bents, and support the middle section of the wharf. The total number of piles supporting the Marginal Wharf is 2,388 piles. The total number of piles supporting the railroad trestle is 102 piles.

References:

Department of Public Works' Drawing No. 28,934
Drawing No. 43-34-176-36
Marginal Wharf - Widening of Loading Platform Drawing No. 43-34-176-36

Department of Public Works' Drawing No. 28,904
Bureau of Yards and Docks Drawing No. 332,152
Drawing No. 43-34-176-3
Marginal Wharf - Piling Plan

Department of Public Works' Drawing No. 28,931
Bureau of Yards and Docks Drawing No. 332,179
Drawing No. 43-34-176-28
Marginal Wharf - Concrete Pile Schedule

Department of Public Works' Drawing No. 29,418
Drawing No. 43-34-176-30
Marginal Wharf - Piling Plan, Changes to Railroad Trestle

FIG. 4 -

MARGIN

CHESNA

WISWE

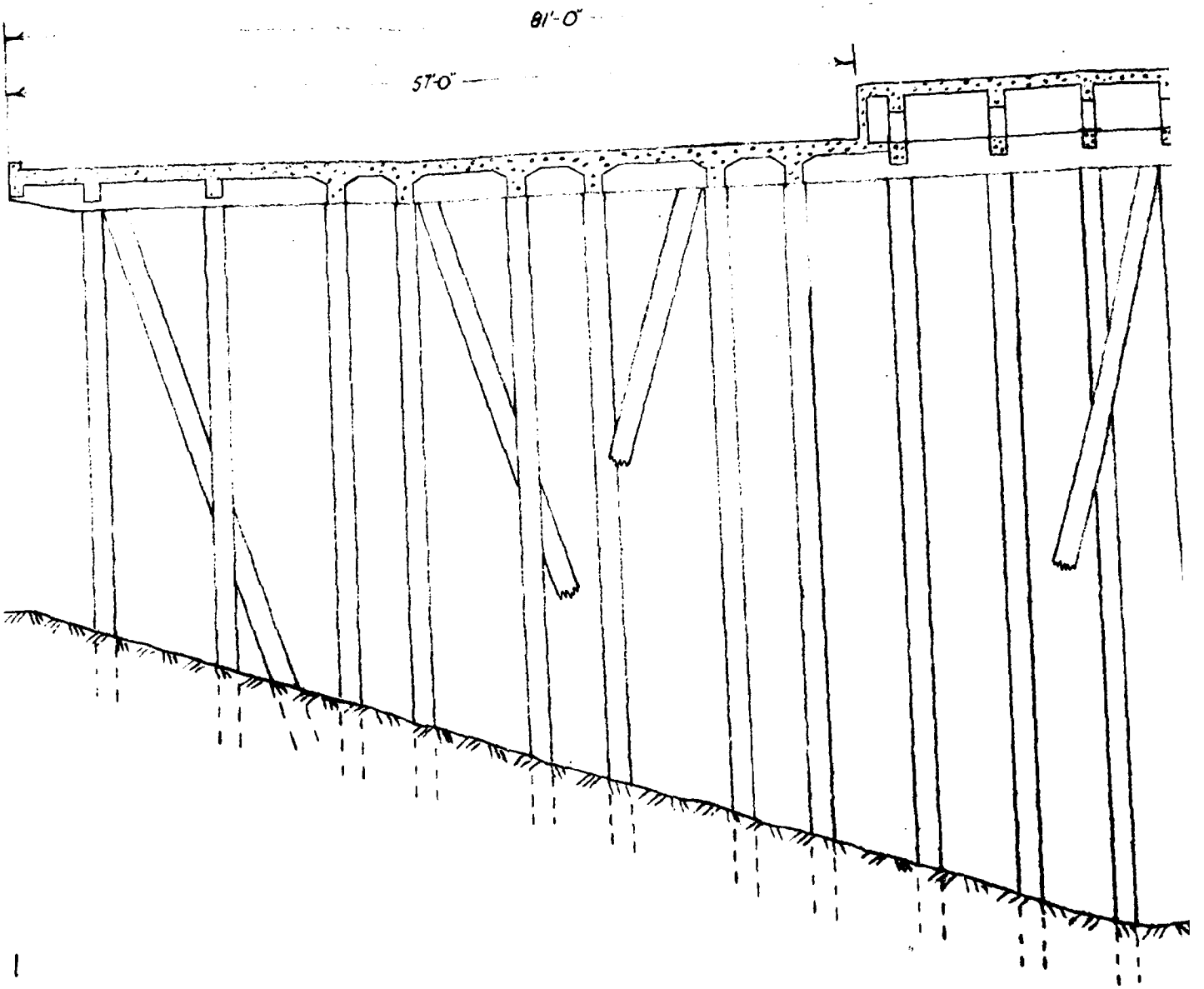

FIG. 4 - TYPICAL WHARF CROSS SECTION - NORTH LEG

MARGINAL WHARF, U.S. NAVY SUBBASE BANGOR

CHESNAVFACENGCOM, FPO-1-80(14), N-62477-80-C-0233

WISWELL, INC., 3280 POST RD., SOUTHPORT, CT. 5/6/81

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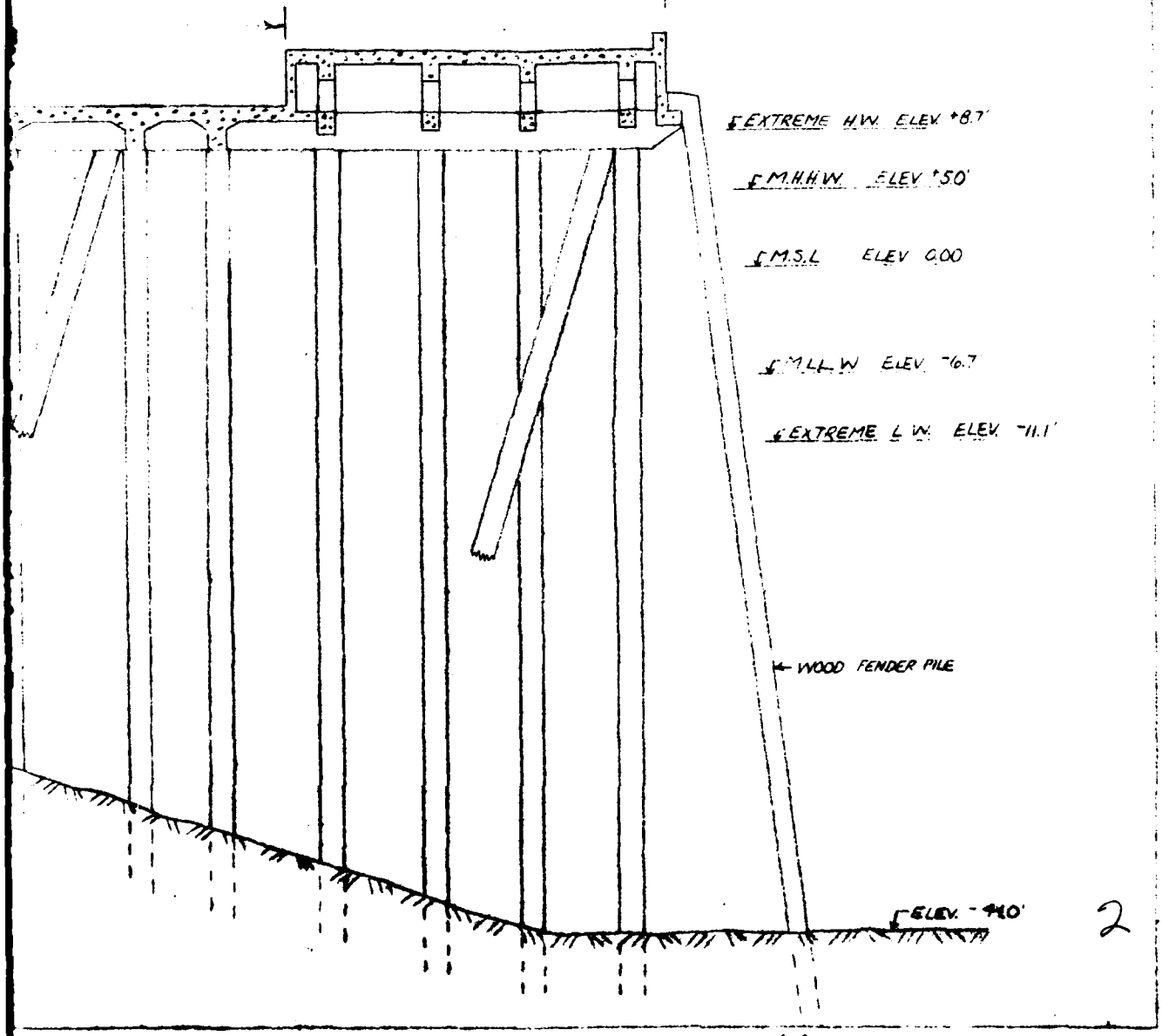

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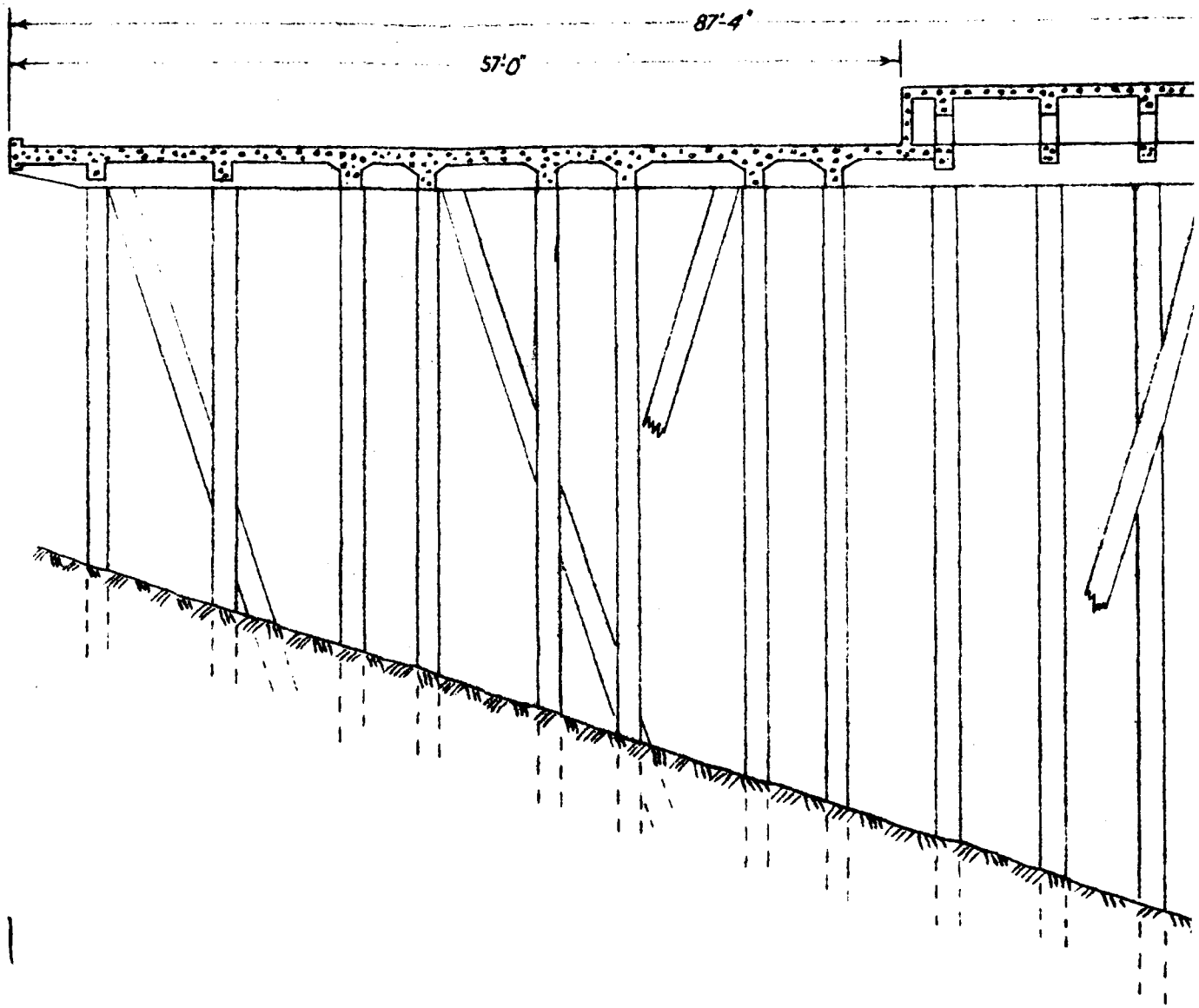

87'-4"
57'-0"

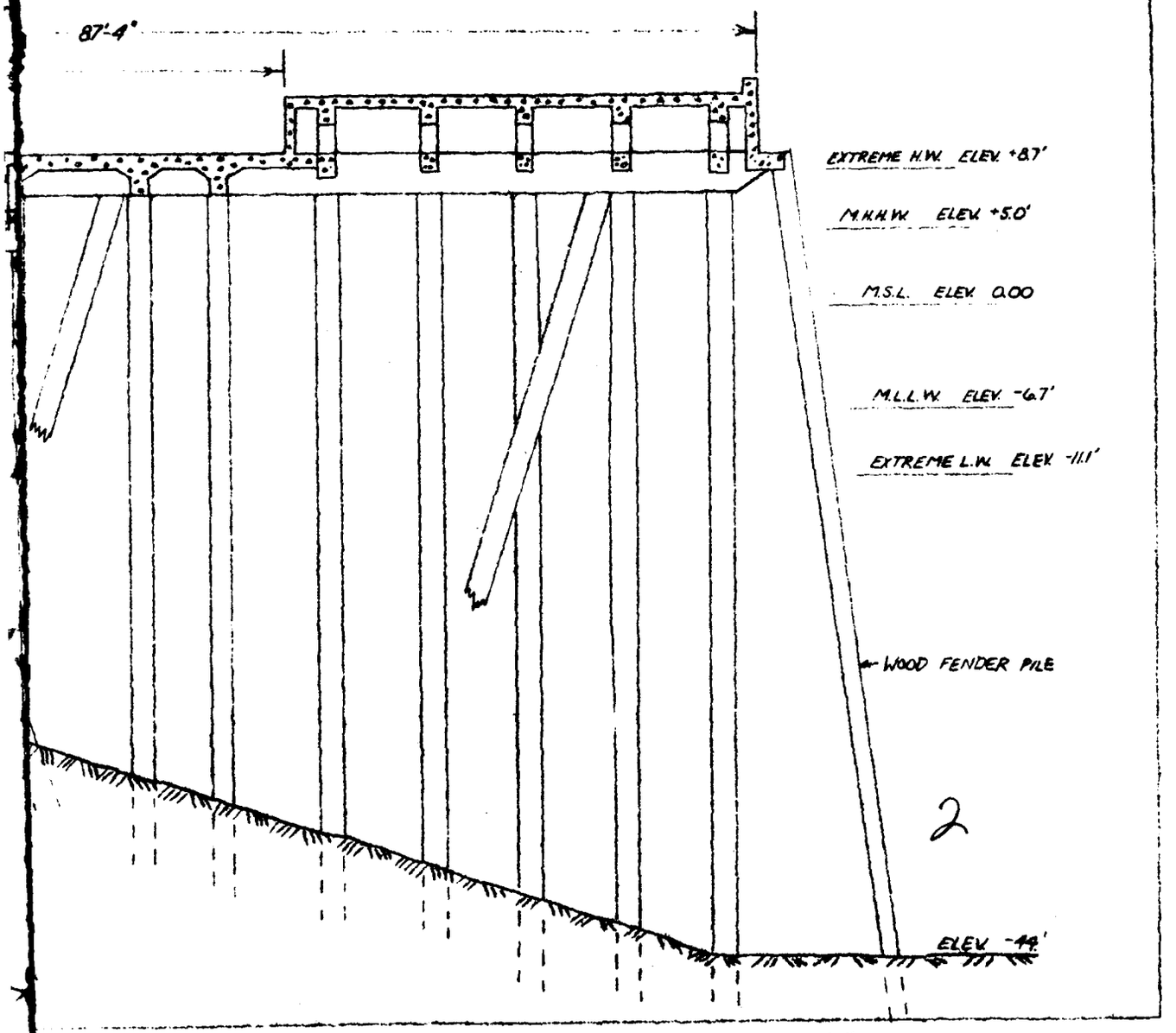
FIG. 5 - TYPICAL WHARF CROSS SECTION - SOUTH LEG

MARGINAL WHARF, U.S. NAVY SUBBASE BANGOR

CHESNAVFACENGCOM, FPO-1-80(14), N-62477-80-C-0233

WISWELL, INC., 3280 POST RD, SOUTHPORT, CT 5/6/81

SCALE 1/8"=1'



Drawing No. 43-34-176-34
Marginal Wharf - Widening of Loading Platform, Reinforcing Steel Details

Department of Public Works' Drawing No. 28,902
Bureau of Yards and Docks Drawing No. 332,150
Drawing No. 43-34-176-2
Marginal Wharf - Location Plan & Road Details

4.1.2 Observed Inspection Condition

The inspection found underwater damage at two piles. The first damaged pile was pile 115-A, which was found to have a double crack at an elevation of 17 feet 6 inches below mean sea level. This pile was also found to have loss of concrete and exposed reinforcing bars, at an elevation 20 feet below mean sea level (see photographs 1, 2 and 3). The second pile with damage was pile 138-A, which was fractured in two locations, causing the pile to be displaced horizontally at one point of damage approximately 20 inches. The concrete in the damaged section was fractured and has fallen away, exposing the reinforcing bars for a length of approximately 12 inches. This damaged area was within the tidal zone and both underwater and above water photographs were taken. (See photographs 4 and 5). It should be noted that both of these piles are located on the A row, or outer row, of the wharf, which is closest to the fender system. This damage appears to be caused by the impact of berthing vessels.

The inspection process of the underwater portion of the concrete piles was hindered by the amount of marine growth present. Marine growth in the tidal zone was particularly heavy (see photographs 6, 7 and 8). Marine growth in the middle region of the piles was much less, consisting mostly of sea anemones and soft marine growths (see photographs 9, 10 and 11). The marine growth present at the mudline was much less, consisting of one inch or less of marine growth (see photograph 12).

Marine growth was scraped away, as necessary, to expose the concrete surfaces. In most cases the concrete piles were in very good con-

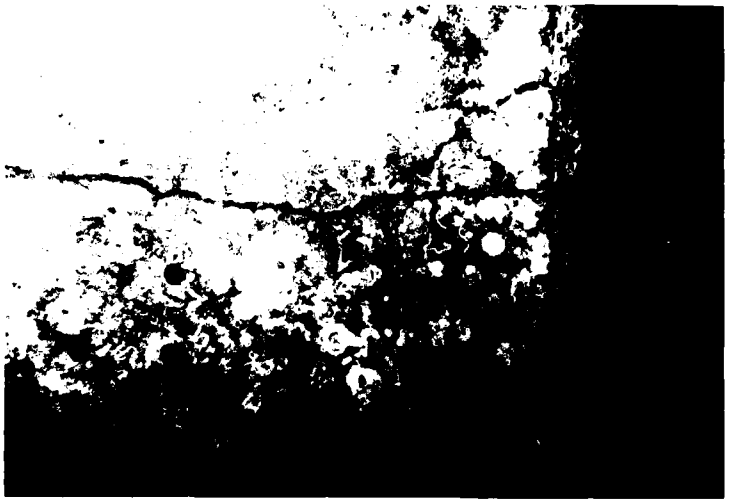


PHOTO NO. 1

Pile 115A - Crack in pile at depth of 17'-6" below mean sea level

PHOTO NO. 2

Pile 115A - Crack in pile at depth of 17'-6" below mean sea level

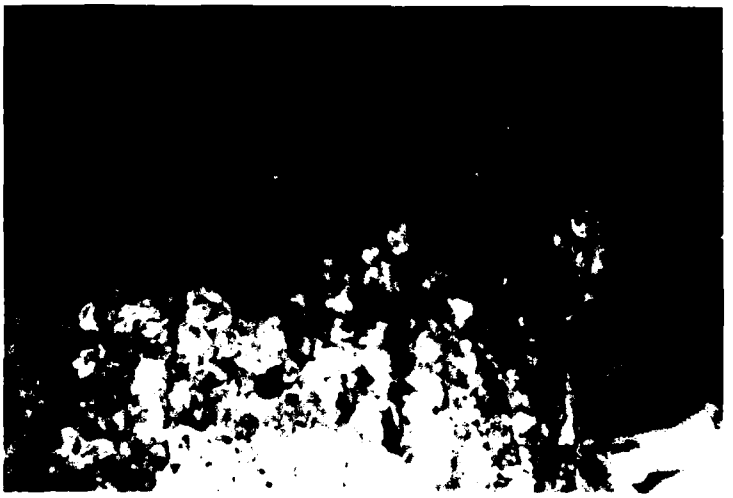


PHOTO NO. 3

Pile 115A - Exposed reinforcing bar at depth of 20 feet below mean sea level adjacent to lower crack in pile.

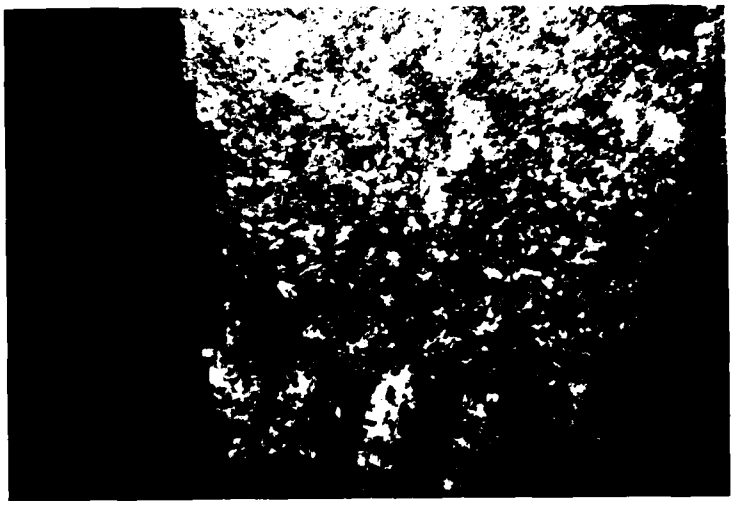


PHOTO NO. 4

Pile 138A - Underwater view of fractured pile showing exposed bent reinforcing bars. Damage is 6 feet from the pile cap. View is of the Southern face of the pile.

PHOTO NO. 5

Pile 138A - Pile fractured in tidal zone with exposed reinforcing bars

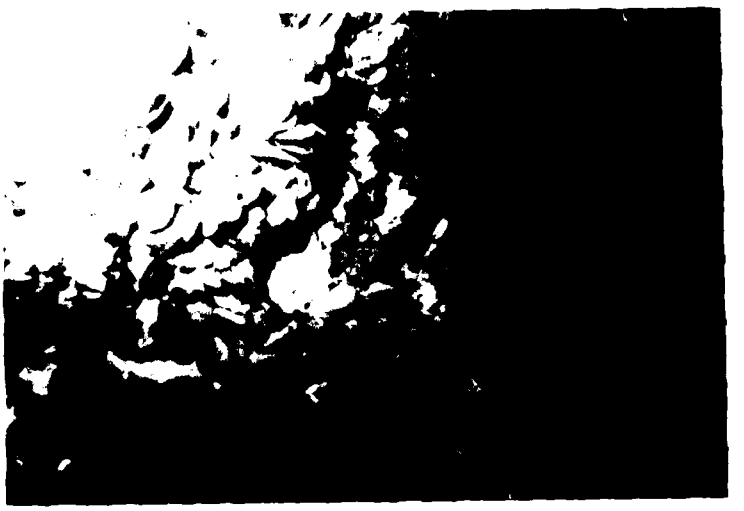


PHOTO NO. 6

Pile 17L - View of typical heavy mussel growth in the tidal zone

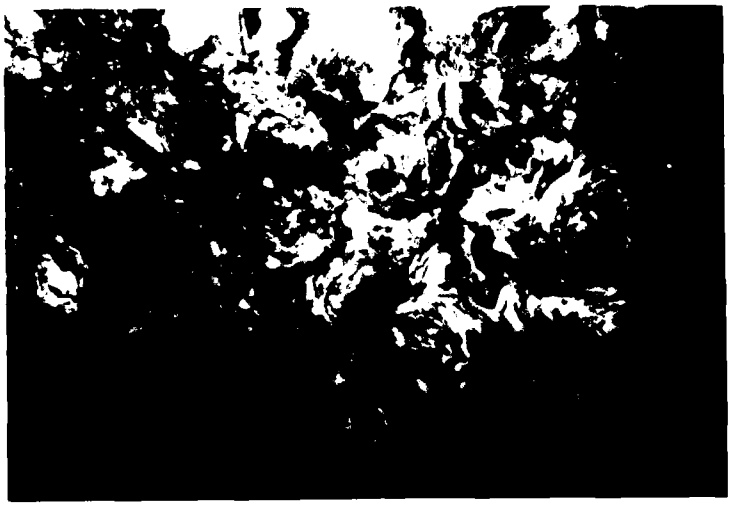


PHOTO NO. 7

Pile 17L - View of typical heavy oyster growth in the tidal zone

PHOTO NO. 8

Pile 25L - Typical marine growth at bottom of tidal zone

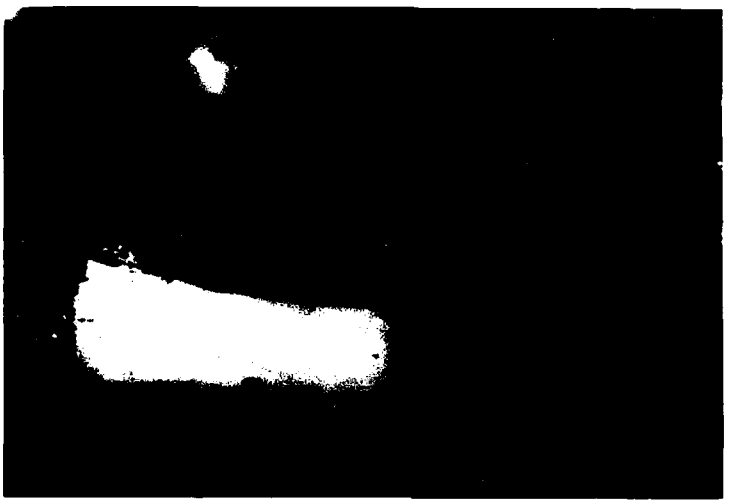


PHOTO NO. 9

Pile 25L - Typical marine growth at depth of 15 feet below mean sea level

PHOTO NO. 10

Pile 25L - Typical marine growth at depth of 15 feet below mean sea level

dition with signs of the sharp edges of the original formwork still readily visible (see photographs 13, 14, 15 and 16).

The inspection of Marginal Wharf included the portion of supporting piles between the highest high sea level and the underside of the pier deck. Due to the tidal range at the facility, this portion of the piles is only accessible during the high tide cycle (see photograph 17). Damage in this area included cracked piles, fractured piles, and completely severed piles. The inspection team found two piles on the railroad trestle which had cracks radiating from the pipe in the pile in a downward direction, which appears caused by a minor failure of the pile. (See photographs 18 and 20.) Additional piles were found to have cracks at or near the junction of the pile and the pile cap. (See photographs 19 and 21.) Some piles had repairs made of the crack, with the placement of concrete on the pile in these locations. Inspection findings are noted on Figures 6 and 7.

A total of eight batter piles were found to have splices near the junction of the pile and the pile cap (See Figures 6 and 7 for listing). These splices were not completely aligned with the axes of the pile. This condition is considered to be the result of the precast concrete pile driven deeper than originally planned and the splice used to make up the additional required length. (See photograph 22).

Several piles were found to have severe structural damage between the mean sea level and the underside of the pier (See Figures 6 and 7 for listing). For the most part, these were piles that had severe fractures or were completely severed from the pile cap. One such pile was pile 138-A, which was broken from the pile cap at the junction of the pile and pile cap. (See photographs 23 and 24.)

One pile was found to be missing concrete at the pile-pile cap junction; this pile, pile 124-A, appeared to have possibly had concrete removed and not replaced or had the concrete in the area shattered. There appeared no signs of major structural damage, yet exposed rebars were present. (See photograph 25).

PHOTO NO. 11

Pile 17J - Heavy marine growth at depth of 16 feet below mean sea level

PHOTO NO. 12

Pile 26L - View of pile at mudline. Depth of 30 feet.

PHOTO NO. 13

Pile 159F - Typical marine growth

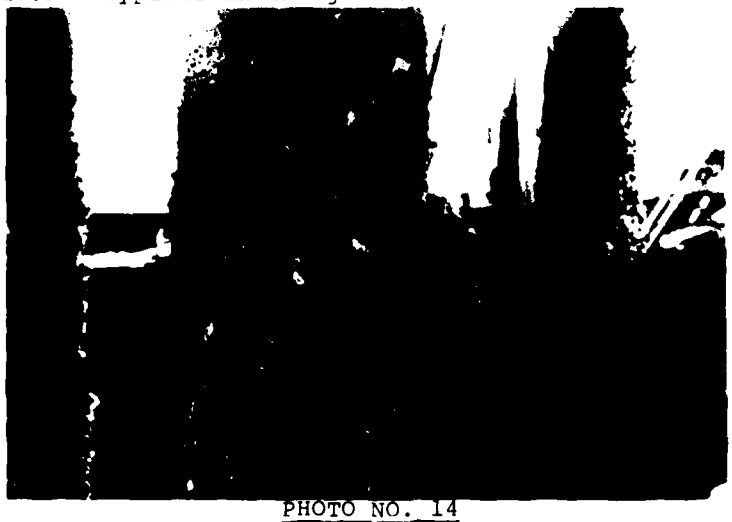


PHOTO NO. 14

Pile 145A - View of pile jacket repair in tidal zone with marine growth removed

PHOTO NO. 15

Pile 159F - With marine growth removed for inspection

PHOTO NO. 16

Pile 162F - Marine growth removed from pile to allow closer inspection

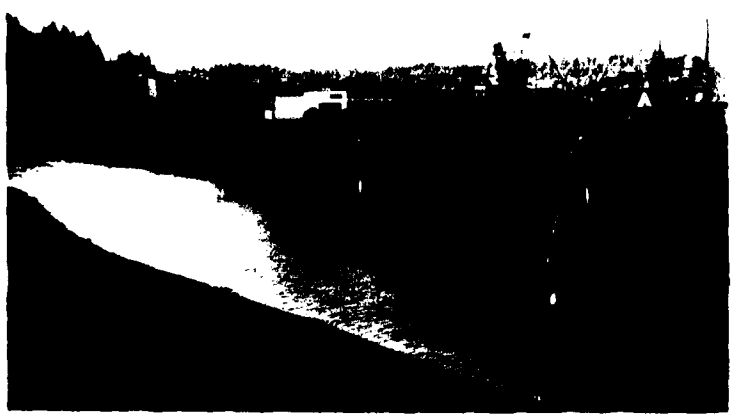


PHOTO NO. 17

View of south leg of Marginal Wharf from shore near Truck Access Trestle

PHOTO NO. 18

Pile 204B on Railroad Trestle - Crack of pile from pipe at interface of pile and pile cap

PHOTO NO. 19

Pile 165C - Minor cracks and spalls at junction of pile and pile cap

PHOTO NO. 20

Pile 19J8 in Railroad Trestle - Crack in concrete 1/8" wide, from pipe section at pile/pile cap interface

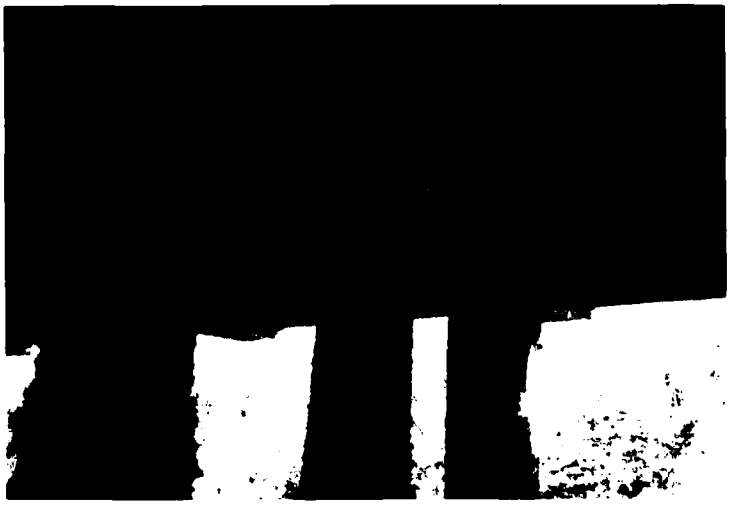


PHOTO NO. 21

Pile 4J - Pile cracked approximately two feet below the pile cap

PHOTO NO. 22

Pile 104V - View of crack and splice of pile where the axis of the pile changes near the pile cap. This condition was encountered on eight batter piles

PHOTO NO. 23

Pile 138A - Pile broken at junction of pile and pile cap

PHOTO NO. 24

Pile 138A - View of pile broken away from pile cap

PHOTO NO. 25

Pile 124A - Loss of section of pile cap exposing reinforcing bars

Other piles that showed severe damage included pile 127-A (see photograph 26) which was displaced some five feet from its original location. This break appears to be a clean break at the pile-pile cap junction. Pile 112-A (see photographs 27 and 28) was found to be heavily damaged at the pile cap, with extensive loss of concrete in the pile cap, and exposed reinforcing bars. Pile 115-A (photograph 29) was found to have an extensive spalled area with exposed rusted reinforcing bars.

Signs of previous repairs to the piles were found at various locations. These repairs consisted of formwork placed around the existing pile and concrete placed within the formwork. Examples of these repairs are piles 145-A (see photograph 14) and pile 142-A (see photograph 30).

4.1.3 Structural Condition Assessment

The purpose of this section is to present a qualitative description of the structural condition of the facility based upon the inspection data. An in-depth inspection of approximately 20% of the piles supporting Marginal Wharf, the railroad trestle, and the approach area, resulted in the location of several field conditions not previously noted in government-furnished information, as well as the location of several piles which had structural damage. Of the 511 piles inspected, only two piles were discovered that had severe structural damage between the mean highest high water line and the mudline. The first, pile 115-A, was found to have two sets of circumferential cracks of approximately 1/8" to 1/4" wide at elevations of approximately minus 15 and minus 17 feet. The cracks were found parallel to each other. The damage appeared relatively recent in that there was no heavy rusting of reinforcing bars, where exposed, and no spalling of concrete. The other pile showing underwater damage was pile 138-A, which was found to be fractured and had severe loss of concrete in the fractured area, exposing many reinforcing bars and tie wires.

PHOTO NO. 26

Pile 127A - Top of pile displaced some 5 feet from original location in pile cap

PHOTO NO. 27

Pile 112A - Pile broken at pile cap exposing reinforcing bars with extensive loss of concrete

PHOTO NO. 28

Pile 112A - Pile broken at pile cap exposing reinforcing bars with extensive loss of concrete

PHOTO NO. 29

Pile 115A - Large corner spall exposing rusted reinforcing bars

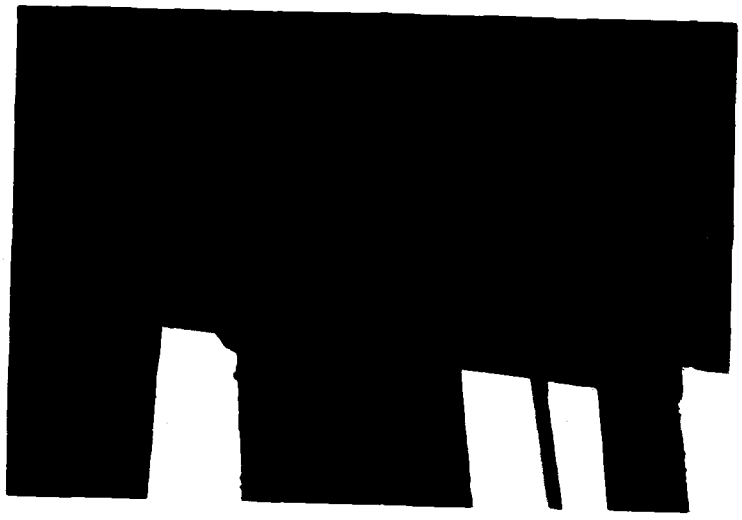


PHOTO NO. 30

Pile 142A - Short pile jacket repair at interface of pile and pile jacket

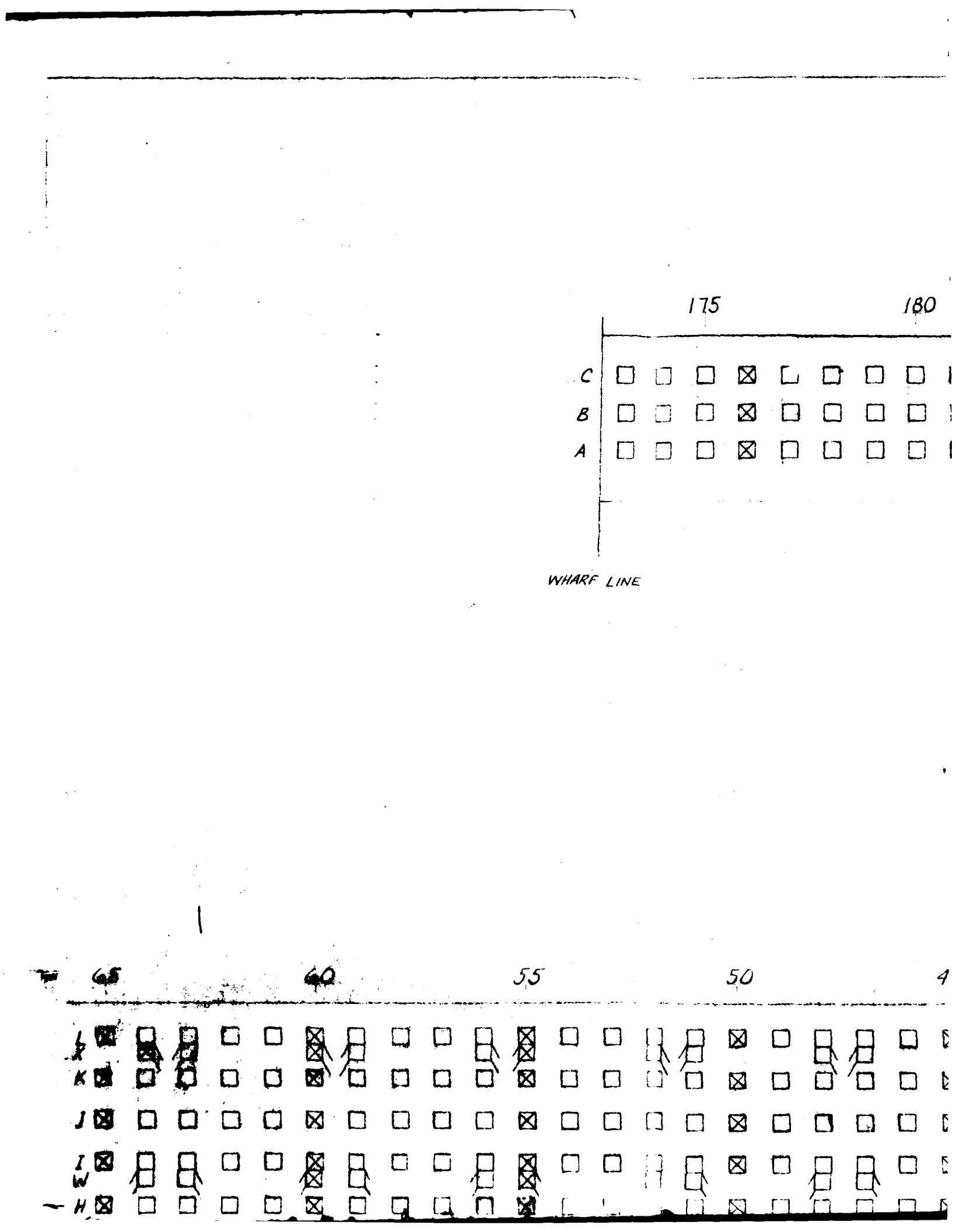
In general, the underwater portion of all the piles, except those noted above, was found to be in very good condition. These piles exhibited sharp, distinct edges, with no signs of erosion, chemical attack, or loss of concrete.

Marginal Wharf was constructed with a design live load limit of 600 pounds per square foot on the wharf deck, and a design load limit of 800 pounds per square foot on the loading platform. These values are based on a pile design load of 40 tons.

In that five single piles showed severe structural damage with no two piles being adjacent, structural analysis shows that the dead load of the non-bearing pile would be transmitted to the adjacent piles in the bent. Dead load transferred would amount to approximately 9 tons. With the wharf load limits remaining as they are with a maximum load limit of 800 p.s.f. on the loading platform, an additional 20 tons could be developed over the non-load bearing piles. This could result in the adjacent piles receiving a loading over their design limit.

To insure that excessive loading condition does not occur, it is our recommendation that area directly above the non-bearing piles be derated and cordoned off to a void heavy loads being placed in these weakened areas. Once the piles have been repaired the load rating would be increased to the original design load once again.

In reviewing the horizontal load capacity of the main pier, it was determined that the wharf retained its original design capacity. Of the 54 batter piles inspected, all were found to be in very good condition, with no signs of damage or deterioration. Inspection found no section loss, no signs of cracks, spalling, exposed reinforcing bars, or any other damage. It must, therefore, be concluded that these piles can withstand their design load limit of 40 tons.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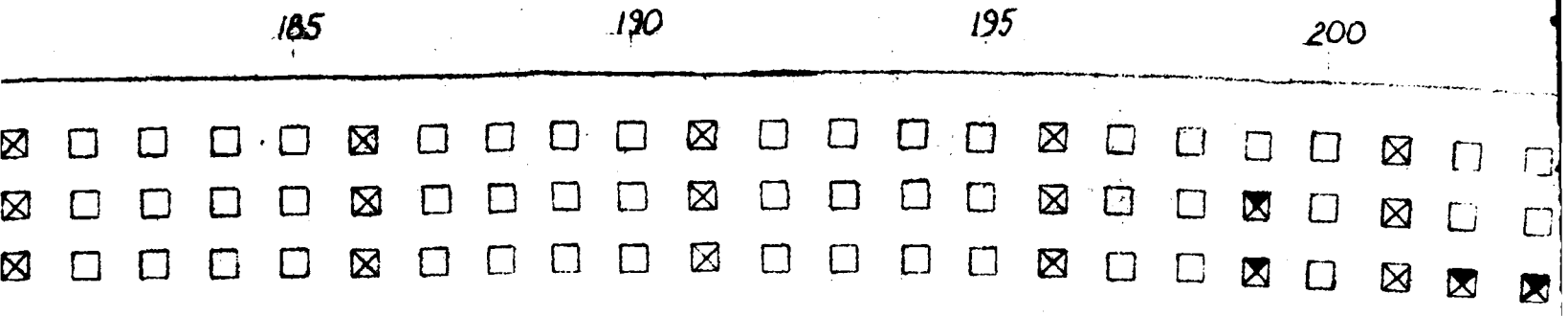

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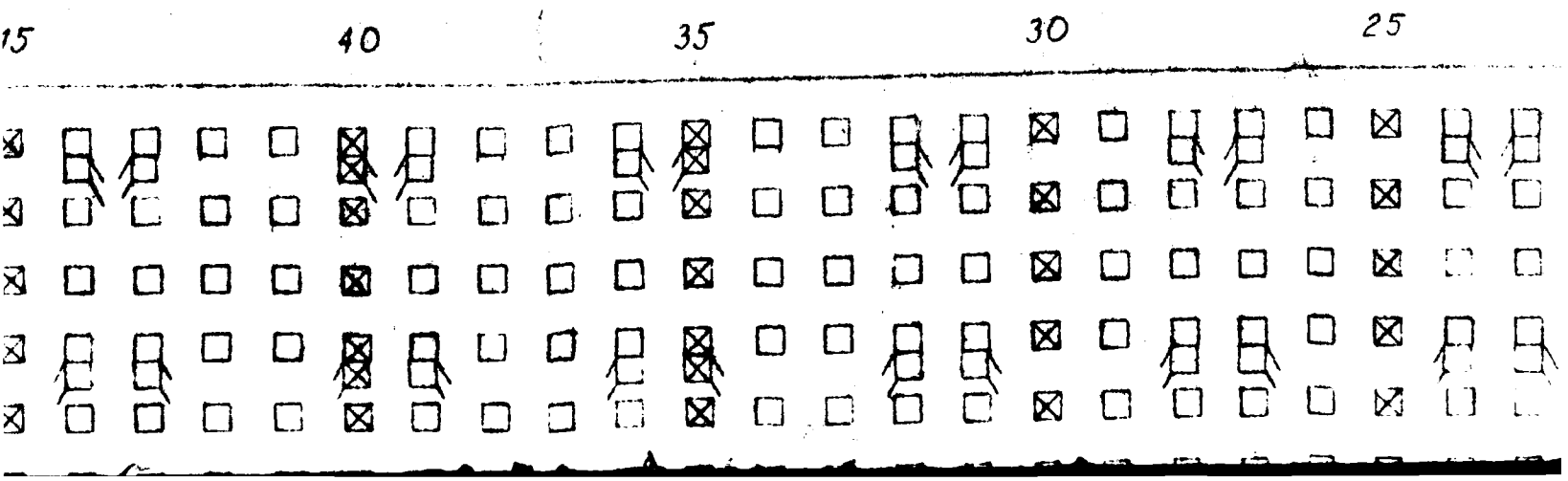

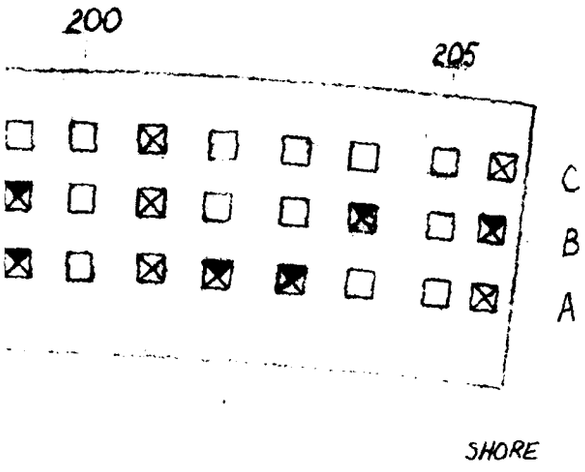
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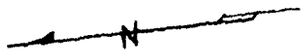
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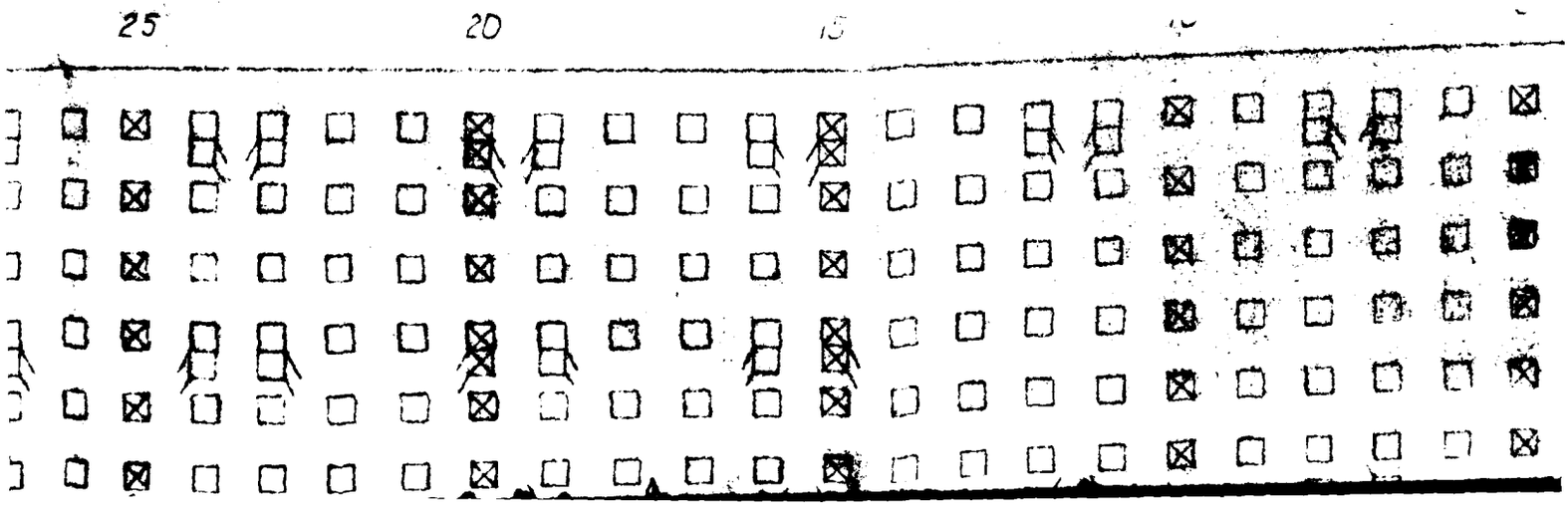
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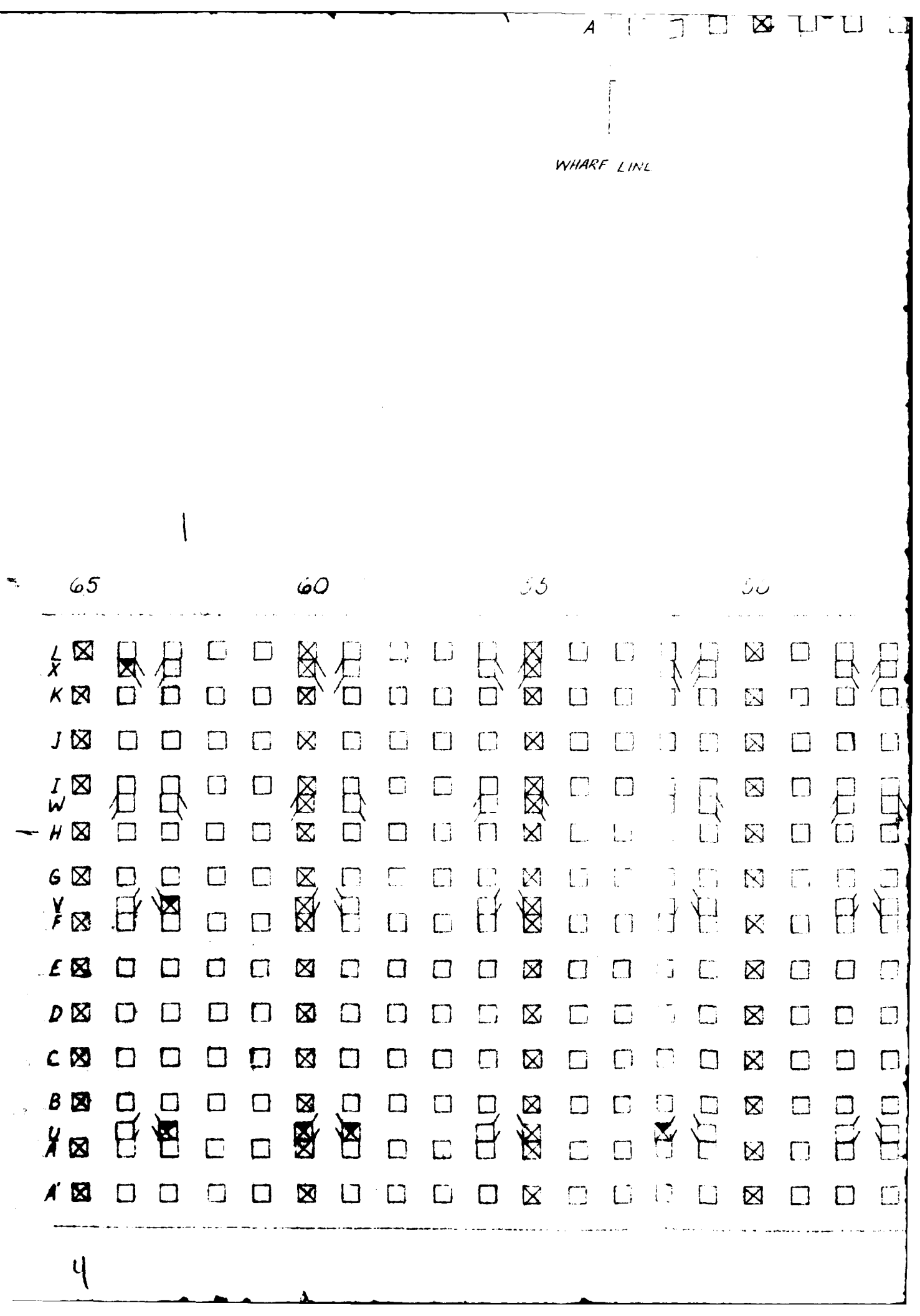
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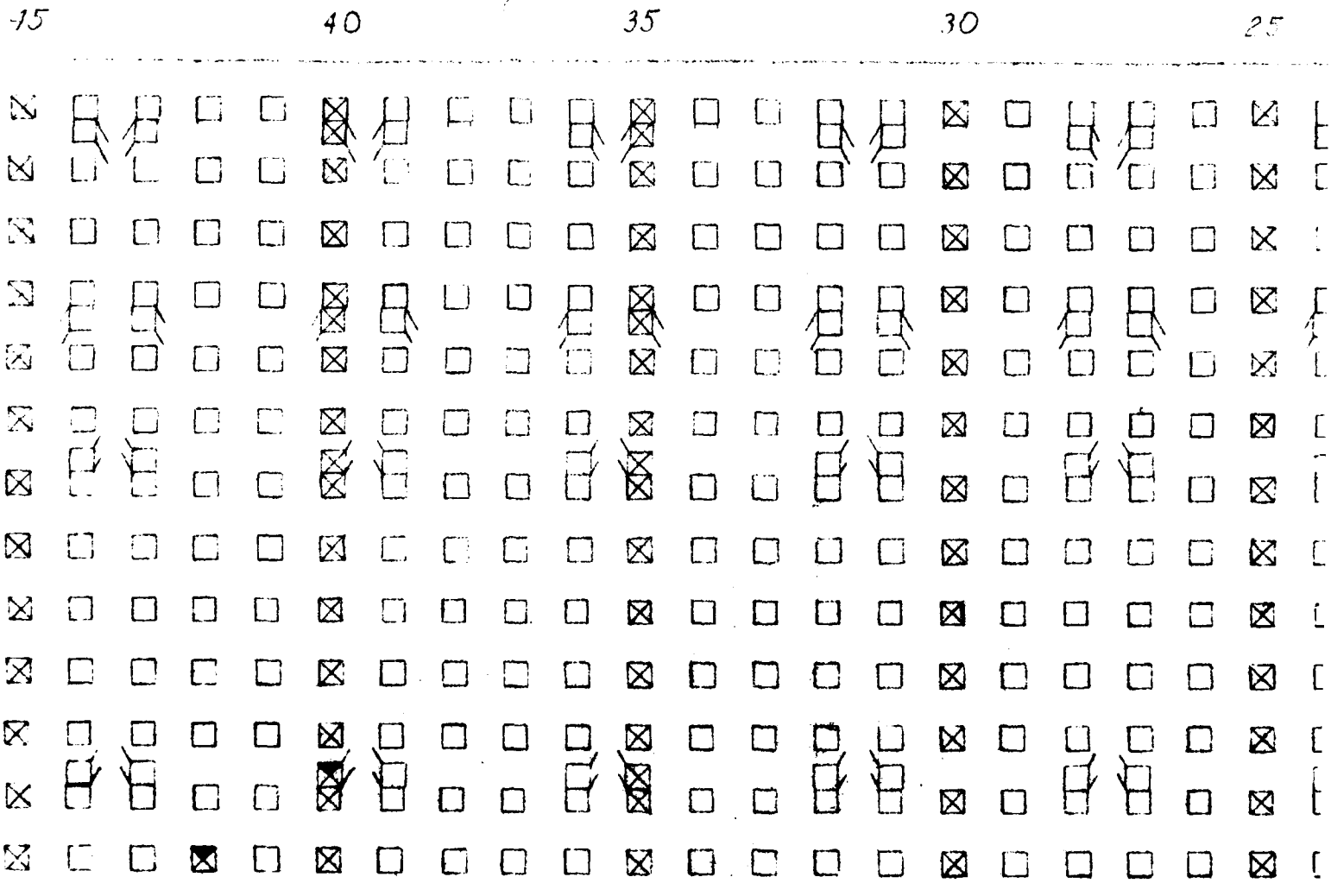

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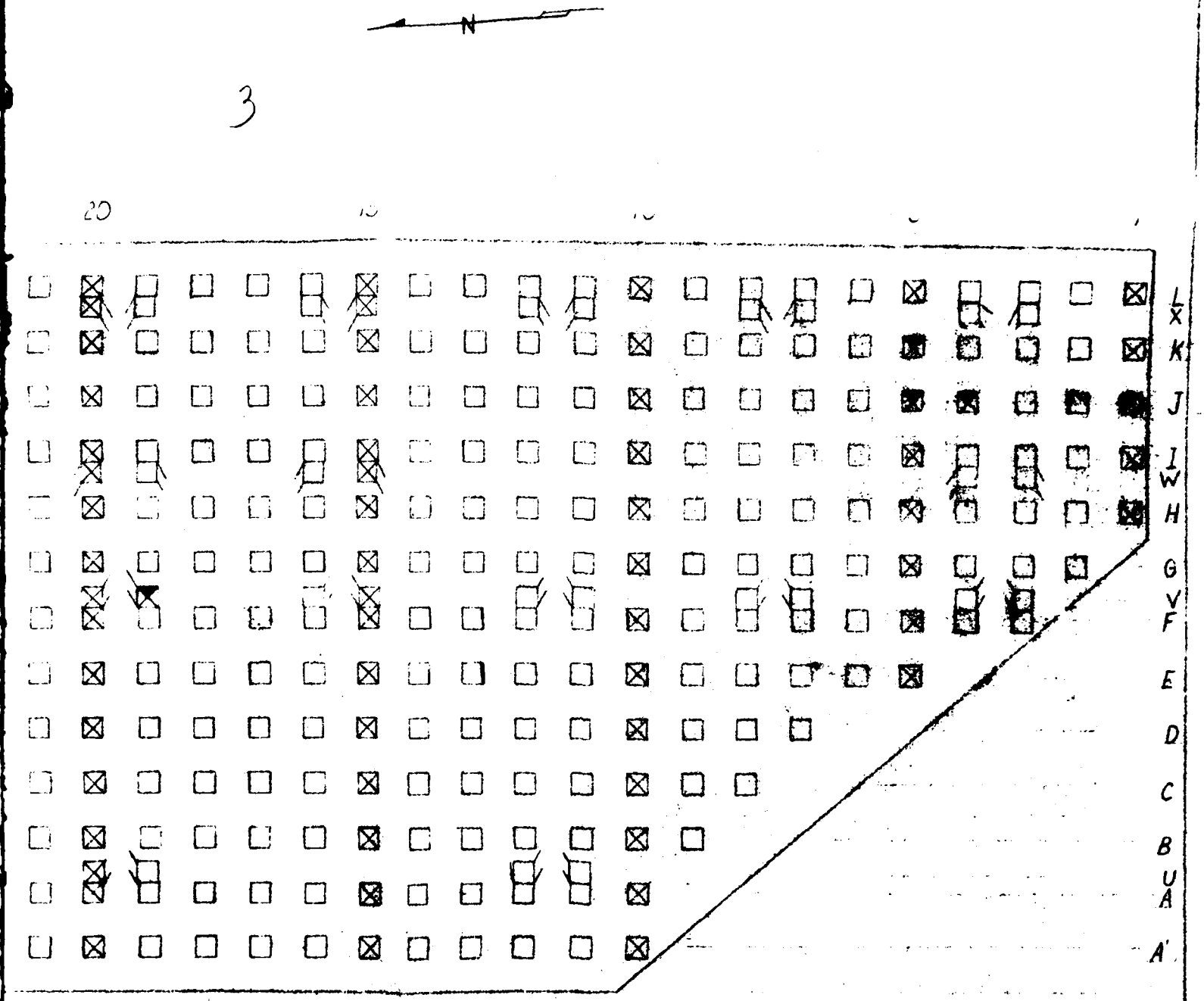


FIGURE 5

MARGINAL WHARF - PILING PLAN, SOUTH LEG
UNITED STATES NAVY SUB BASE, BANGOR, WASHINGTON

CHESNAVFACENGCOM FRD-1-80(14), N-62477-80-C-0253	DATE - 8-6-81 SCALE - NOT TO SCALE
WISWELL, INC. 3280 POST RD., SOUTHPORT, CT	DRAWN BY RHJ APPROVED BY GCW
REVISED 5-6-81 RHJ	DRWG 1 OF 2

EY

ED, GOOD CONDITION

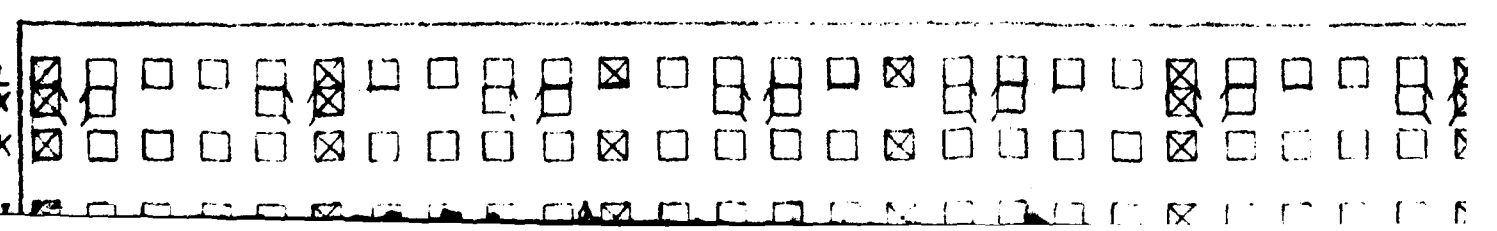
ED, MINOR DAMAGE OR
ON NOTE (SEE APPENDIX) 6

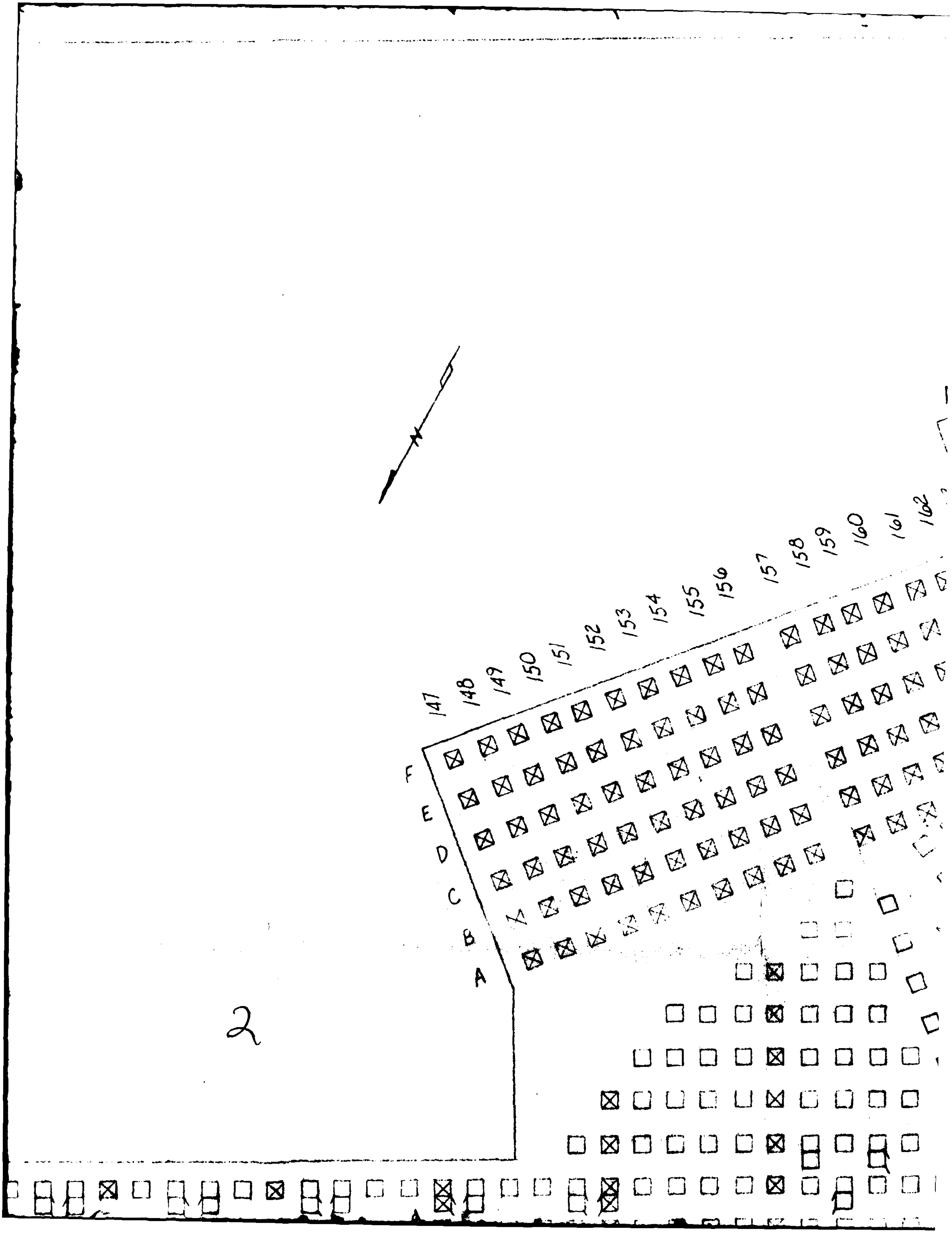
ED, MAJOR DAMAGE
TEXT)

SPECTED

KEY

- ☒ PILE INSPECTED, GOOD CONDITION
- ☒ PILE INSPECTED, MINOR DAMAGE OR CONDITION NOTE (SEE APPENDIX)
- ☒ PILE INSPECTED, MAJOR DAMAGE (SEE TEXT)
- ☐ PILE NOT INSPECTED





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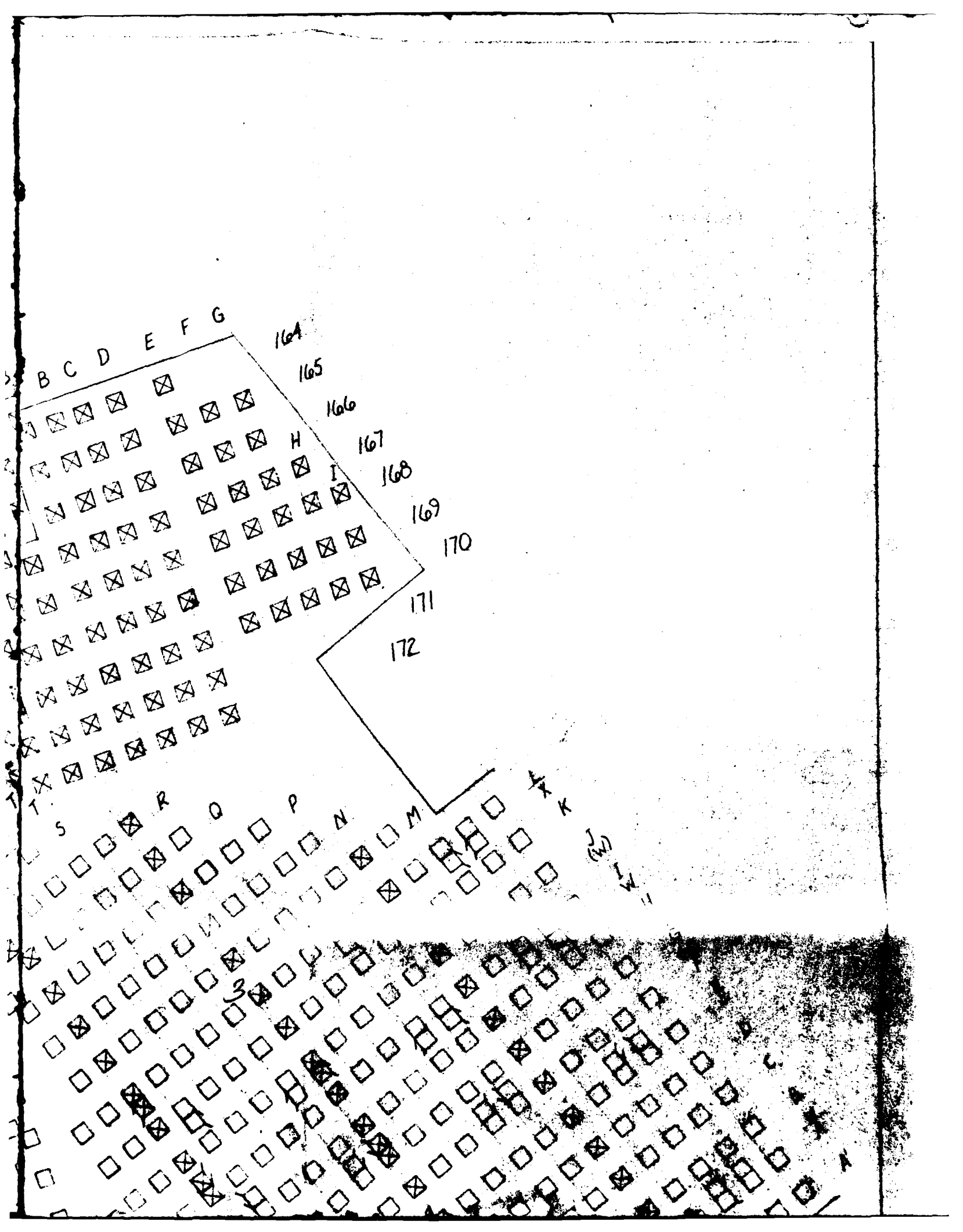
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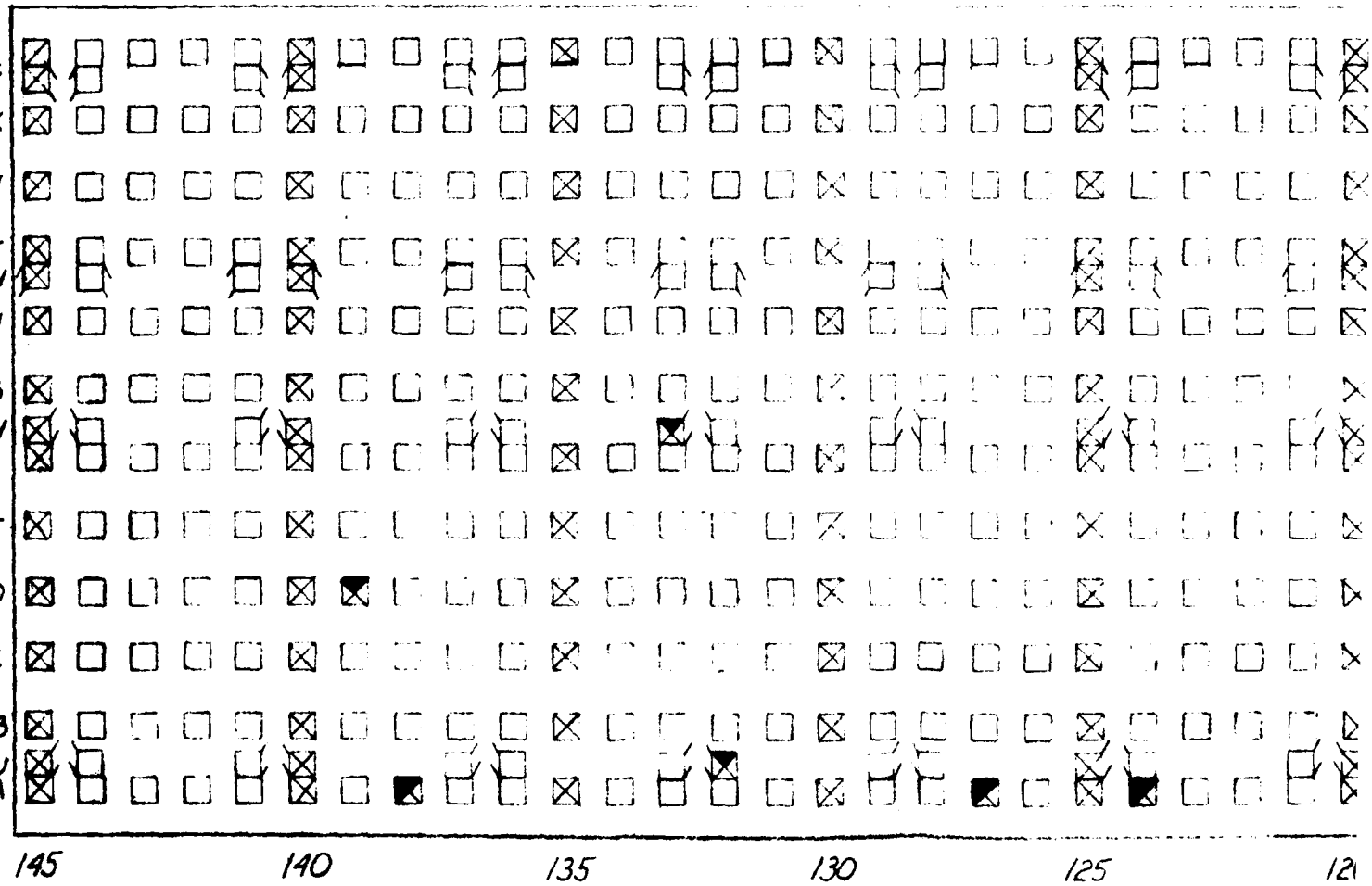
KEY

- ☒ PILE INSPECTED, GOOD CONDITION
- ☒ PILE INSPECTED, MINOR DAMAGE OR CONDITION NOTE (SEE APPENDIX)
- ☒ PILE INSPECTED, MAJOR DAMAGE (SEE TEXT)
- ☐ PILE NOT INSPECTED

1



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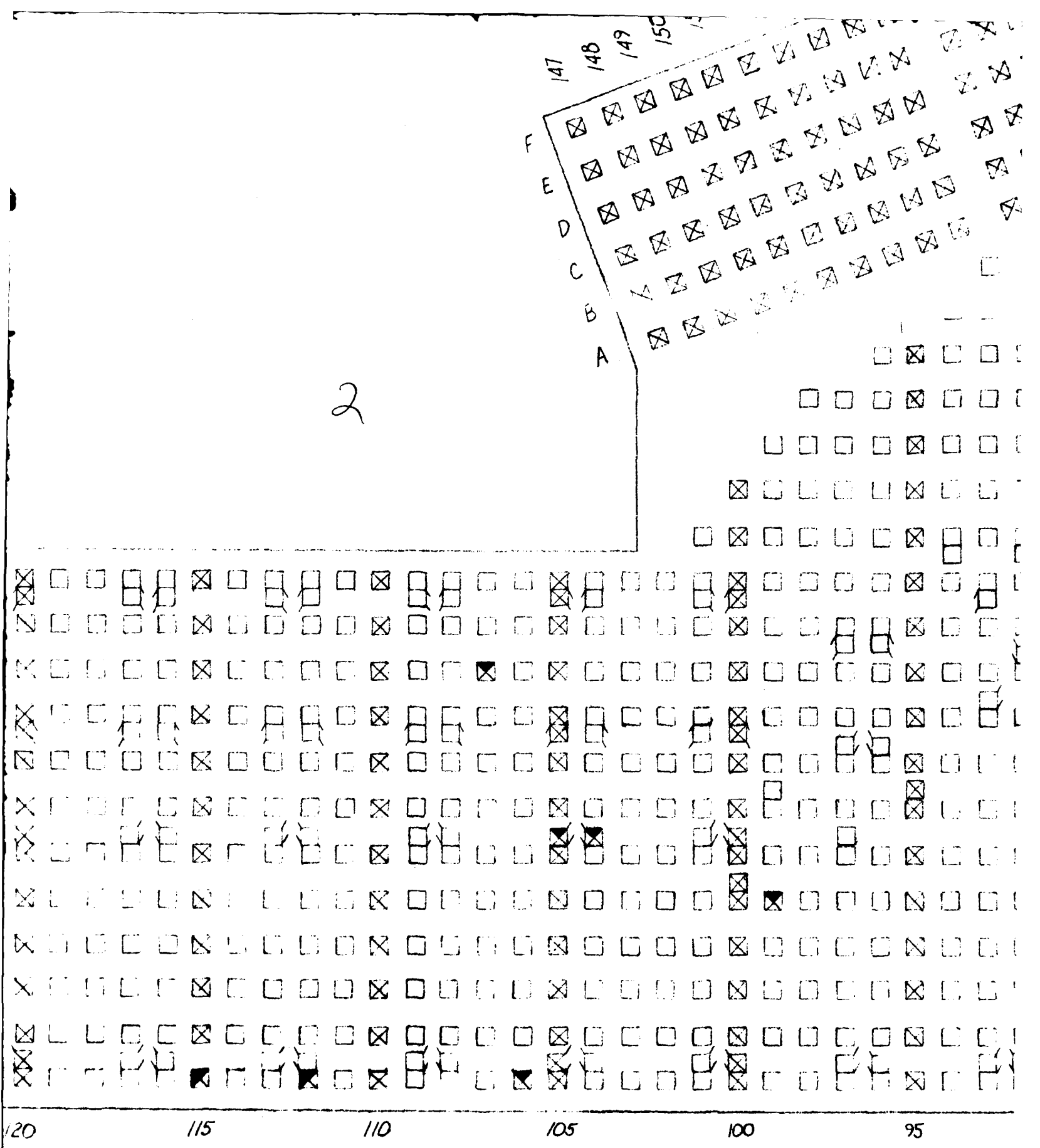
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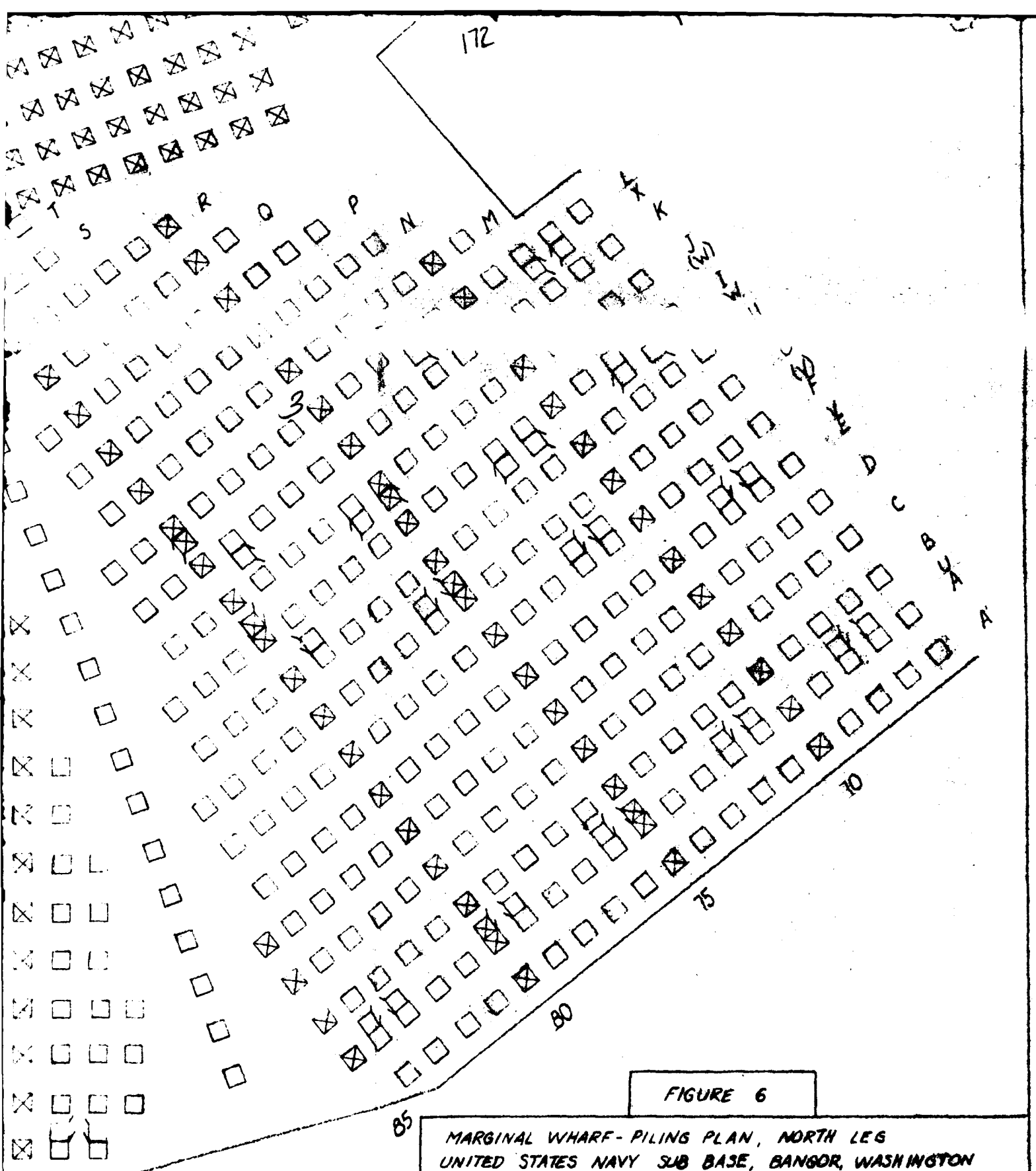

FIGURE 6

MARGINAL WHARF - PILING PLAN, NORTH LEG UNITED STATES NAVY SUB BASE, BANGOR, WASHINGTON	
CHESNAVFACENGCOM FPO-1-80(H), N-62477-80-C-0233	DATE - 3-6-81 SCALE - NOT TO SCALE
WISWELL, INC. 3280 POST RD., SOUTHPORT, CT.	DRAWN BY RMJ APPROVED BY BCW
REVISED 5-6-81 RMJ	DRWG 2 OF 2

6

4.1.4 Recommendations

The purpose of this section is to recommend action which should be taken to correct existing problems discovered by the inspection.

Based on the analysis and review of the pile capacities, it is recommended that, although no restrictions be placed on the wharf at this time, the wharf repair work be scheduled. The following piles were found to have severe structural damage and should be repaired as outlined:

Pile No.	Recommended Repair
112A	Remove upper section of pile, dowel rebar in cap and splice pile to pile cap with concrete.
115A	Cracks cleaned and high-strength epoxy injected. Pile jacket of five-foot length over epoxied crack. Concrete cover over topside exposed reinforcing bars.
124A	Rebar and concrete cleaned, area formed and concrete placed to complete pile - pile cap connection.
127A	Pile requires further inspection. Repair depends on cause of displacement. If circumferential cracks below surface are found, suggest same repair as Pile 115A. Also, pile cap may require extension to encompass pile. This connection to include reinforcing doweled into pile and encompassed in pile cap form.
138A	Upper 14 feet of pile to be removed and replaced by a cast in-place concrete splice with reinforcing bars doweled into both existing pile below, and the existing pile cap above.

The estimated cost of the repairs as outlined above, would cost approximately $15,000, based on current prices. An alternate repair technique that would be cost-effective is not available. The repair cost estimate is broken down as:

Material and Equipment	$ 3,500
Labor	$ 11,500

It is our recommendation that a further inspection be scheduled some time in the future, encompassing the outer two piles in each bent (i.e. 138-A, 138-B or 33-A', 33-A), in that the inspection found all structural damage in the outer pilings under the wharf. It is our recommendation that these piles, in particular, merit continued inspection and assessment.

TABLE OF CONTENTS FOR APPENDIX

INSPECTION DATA

Damage was found on several piles. Most of the damage was located between the Mean High Water line and the pile cap, while other damage was found below the surface. The following piles were found to have damage, irregular conditions, or deterioration:

RAILROAD TRESTLE

Pile 206B - Minor spalling at top of pile and pile cap.

Pile 204B - Crack extending diagonally from pipe section in pile (see photographs in Appendix).

Pile 203A - Two hairline cracks some 18 inches apart, circumferentially around pile.

Pile 202A - Two hairline cracks some 18 inches apart, circumferentially around pile.

Pile 199A - Cracks near pile cap, 1/8 inch to 1/4 inch wide. (see photograph).

Pile 199B - Cracks near pile cap, 1/8 inch to 1/4 inch wide, extending from pipe section.

MARGINAL WHARF

Pile 1J - Poor concrete in pile from 12 inches to 18 inches below cap.

Pile 4J - Crack some 24 inches below pile cap, 1/8 inch wide. (see photograph).

Pile 5K - Apparent minor concrete patch repair of previous damage.

Pile 5J - Apparent minor concrete patch repair of previous damage.

Pile 19V - Minor spalling with exposed reinforcing bars.

Pile 40U - Pre-cast pile too short, tapered upper end partially exposed.

Pile 42A'- Corner of pile missing, no exposed reinforcing bars.

Pile 52U - Apparent minor concrete patch - repair of previous damage.

Pile 59U - Batter pile spliced during original construction, axes of pile sections change.

INSPECTION DATA CONT'D.

Pile 60U - Batter pile spliced during original construction, axes of pile sections change.

Pile 63U - Batter pile spliced during original construction, axes of pile sections change.

Pile 63V - Minor spalling with partial concrete patch, 18 inches from pile cap.

Pile 64X - Minor crack and spalling at top of pile.

Pile 99E - Crack on one face of pile, two inches wide, tapering to 1/8 inch wide.

Pile 104V - Batter pile spliced during construction, axes of pile sections change. (see photograph).

Pile 105V - Batter pile spliced during construction, axes of pile sections change.

Pile 106A - Vertical pile is spliced 3 feet from cap, axes of pile sections change.

Pile 107J - Apparent minor concrete patch repair of previous damage, 8 inches from pile cap.

Pile 112A - Upper end of pile displaced causing severe damage to cap. Possible failure of pile at lower elevation. (see photograph).

Pile 115A - Large corner spall 4 inches deep by 18 inches long, exposed reinforcing bars. (see photographs).

Pile 124A - Pile - pile cap intersection never complete, concrete missing. (see photograph).

Pile 127A - Pile displaced some 5 feet from original position, possibly fractured. (see photograph).

Pile 132U - Batter piles spliced during original construction, axes of pile sections change.

Pile 133V - Batter piles spliced during original construction, axes of pile sections change.

Pile 138A - Pile broken at cap and seven feet below the cap. (see photograph).

Pile 139D - Poor concrete in pile, 6 inches from cap.

Pile 141 - Pile cap between B and C is spalled 8 inches by 24 inches, reinforcing bar exposed.

Pile 142A - Small concrete pile jacket repair at pile cap. Large concrete pile jacket at 7 feet below pile cap. (see photograph).

Pile 145A - Concrete pile jacket in tidal zone.

DEAD LOAD CALCULATIONS

Pier cross sectional area (concrete):	Total Area (sq.ft.)
Deck - 7.5" x 59'	36.9
Beams - 12" x 22", 12" x 22", 14" x 28", 14" x 28", 14" x 28", 14" x 28", 14" x 28", 12" x 18", 12" x 14", 12" x 14", 12" x 14", 12"x14"	26.2
Curbs - 8" x 8", 6.5" x 10"	0.9
Wall - 6" x 44"	1.8
Loading Platform - 8" x 30' 4"	20.2
Platform Beams - 12" x 22", 12" x 22", 12" x 22" 12" x 22", 12" x 22"	9.2
Bumper Wale - 6" x 50"	2.1
Average Area of Wharf Section=	97.3 ft.^{2}

Pile Cap (volume) = 22"x28"x87'4" = 373.6 ft.^{3}

Dead load per bent = [(area of section) (distance between bents) + Volume of Pile Cap] (density of concrete)

= [(97.3 ft.^{2}) (10.0 ft.) + 373.6 ft.^{3}] (150 lb./ft.^{3})

= 201,990 lb.

Average dead load per pile = $\frac{201,990 \text{ lb.}}{13 \text{ piles}}$ = 15,538 lb.

= 15.5 kips

LIVE LOAD CALCULATIONS

Average deck area per bent - 570 $ft.^2$
Live load for deck - 600 $lb./ft^2$
Deck live load = (570 $ft.^2$) (600 $lb./ft^2$) = 342,000 lb.

Average Platform area per bent - 303 $ft.^2$
Live load for platform - 800 $lb./ft.^2$
Platform live load = (303 $ft.^2$) (800 $lb./ft.^2$) = 242,400 lb.

Total live load per bent = 342,000 lb. + 242,400 lb.
= 584,400 lb.

Live load per pile = $\frac{584,400 \text{ lb}}{13}$ = 44,950 lb.

Average dead load per pile = 15,538 lb.

Total load per pile = 60,488 lb. = 60.5 **kips**

PILE LOAD SUMMARY

The working load capacity of the undamaged piles, based on the maximum exposed length of 55 ft., and allowing an additional length of 5 feet to the point of fixity below the mudline is about 80.0 tons per pile. This is assuming fixed ends, with no sideways permitted (i.e. batter piles are effective).

It is important to note that lateral loads will also be applied to these piles, so the indication of sufficient vertical load capacity is not necessarily a measure of the overall adequacy of the piles. In that piles have been determined to be in very good condition and were driven to a 40 ton load per pile, excessive loading above this figure would cause slippage of the piles versus structural failure of the piles themselves.

END

DATE
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